Oligarchs And Their Government Officials Lie To Protect Their Energy Stock Holdings

A collection of news articles, and reports, setting to rest, once and for all, the facts about fuel cell products:

The Thing That a Couple of Technology Billionaires Will Do Anything To Sabotage

> Certain, known, technology billionaires spend billions of their dollars, per year, flooding blogs with anti-hydrogen lies because they don't have the products to beat it in the competitive market place. Their tactics are detailed in the feature film, ***The Merchants of Doubt,*** available now on **Netflix** and other Movie-on-Demand sites
>
> Some battery VC's, who are campaign financiers, have put moles in competitors, bribed senators and black-balled start-ups to keep you, the public, from getting clean energy-products
>
> Now the FBI, The U.S. Senate, and the entire Japanese and European auto industry have called these *"Solyndra-scammers"* out and the Hydrogen cars are now on sale! The world has said: ***"The lying Lithium battery billionaires are full of BS!"***

Here are the federally, and university, proven facts:

Lithium-ion batteries blow up spontaneously. They set homes, offices and planes on fire and have crashed multiple jets. They release cancer-causing, brain damaging, fetus mutating fumes when they burn. They kill the factory workers and nearby towns, where they are made, due to deadly toxins used in making them. They cause one to invade other countries in order to make them. They poison the Earth when they are manufactured and when they are disposed of. A "certain" group of Silicon Valley campaign financiers pushed for the invasion of Afghanistan, and Bolivian political fractures in order to take over the lithium mineral mines for their monopoly of these batteries. Those billionaires **"War Profiteered"! And paid** U.S. Senators with stock in their companies related to lithium ion batteries.

The greedy VC's didn't do their homework. They didn't see that the lithium ion was such a disaster. They only saw dollar signs. They now spend over a billion dollars per year to sabotage, troll, meat puppet and anti-blog any competing sustainable energy technology because..MONOPOLY!

So that idea "blew up", literally. A famous battery car billionaires is, point-blank, **LYING** about hydrogen and fuel cells in order to protect his lithium battery Afghanistan mining scam.

So What's next?

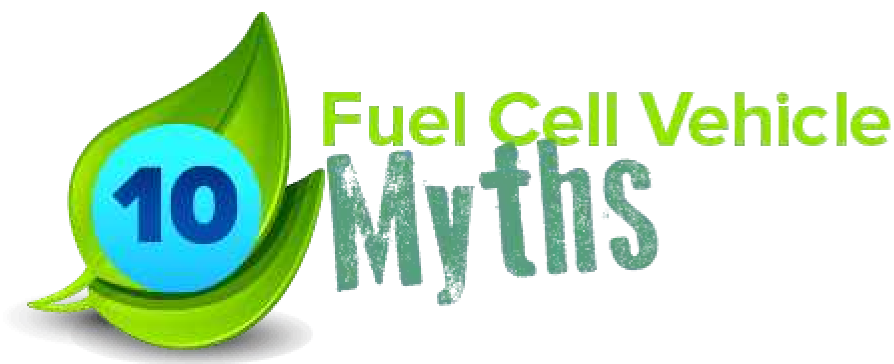
Wouldn't it be cool if you could provide the fuel stock, for the next generation of automobiles, from the water and waste materials that you generate at home?

Wouldn't it be cool if you could drive your next generation car across the nation with fuel you can carry on board, or pick-up from any grocery store?

Wouldn't it be cool if the only waste material that car gave off was simple water?

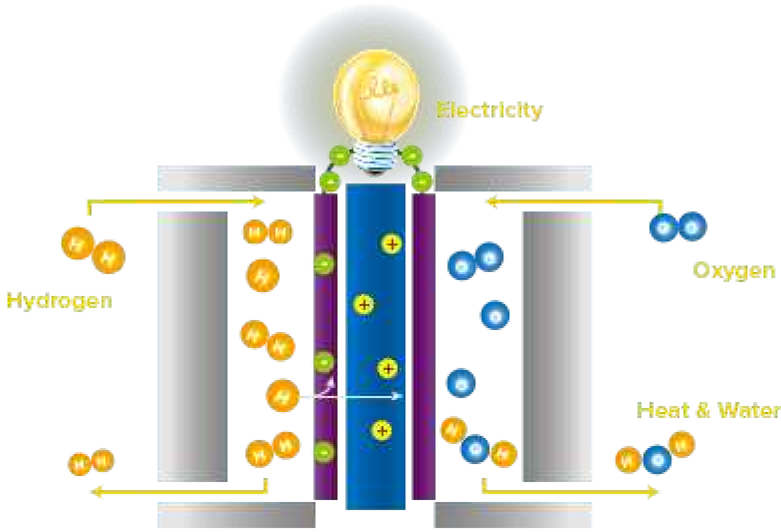
WELCOME TO COOL! WELCOME TO GETTING: BACK TO THE FUTURE! WATCH THIS VIDEO:

https://videos.files.wordpress.com/GlyLVuI9/toyota-fuel-cell_fmt1.ogv



With Toyota and others offering fuel cell powered vehicles in 2015, it's time to tackle some myths about fuel cells and the vehicles that will use them.

Myth #1: Fuel Cell Vehicles Burn Hydrogen



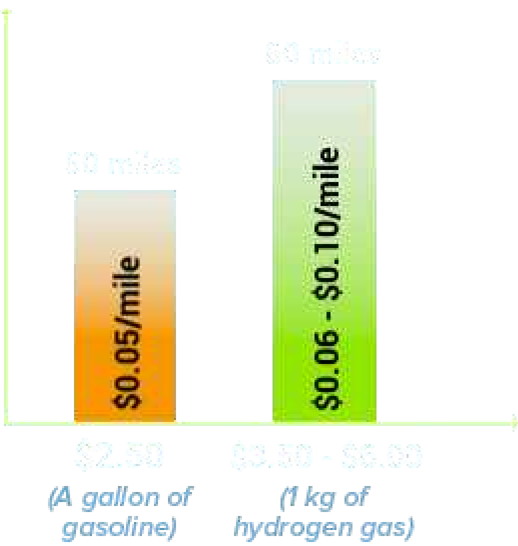
Fuel cells don't burn hydrogen - they use an electrochemical process to convert hydrogen and atmospheric oxygen into electricity and water. They have no moving parts and no open flames.

Myth #2 Fuel Cell Vehicles Are Expensive

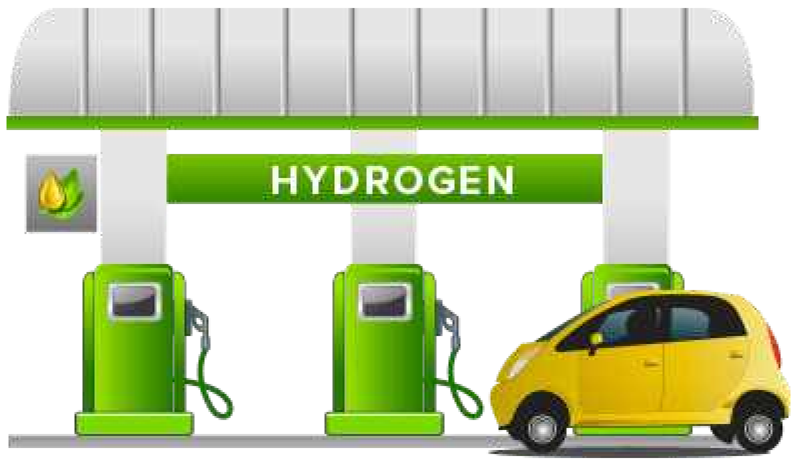
This *used* to be true - a prototype 2007 Toyota FCV reportedly cost more than $1 million dollars to build.

However, recent advances in fuel cell manufacturing and catalyst performance have led to a dramatic cost decrease. According to the US Dept. of Energy, fuel cells will cost $30-$50 per kw of output by 2020, depending on production volume. To put this number in perspective, Tesla battery packs are estimated to cost over $250 per kw-hr of capacity today and may fall to $196/kWh by 2018. Some optimists belive battery pack costs could fall to $100/kWh by 2025, while others believe battery pack costs will fall no lower than $167/kWh by 2025. The point? A mid-sized car with a 60kWh battery pack will likely cost more than a similar sized car with a 125kW fuel cell, all things being equal. Fuel cell cars might not be "cheap," per se, but they likely won't be any more expensive than battery powered vehicles (and could be a great deal less).

Page 4 EXHIBIT 95 – Case # 22-cv-1107-TSH, Norcal 9th District



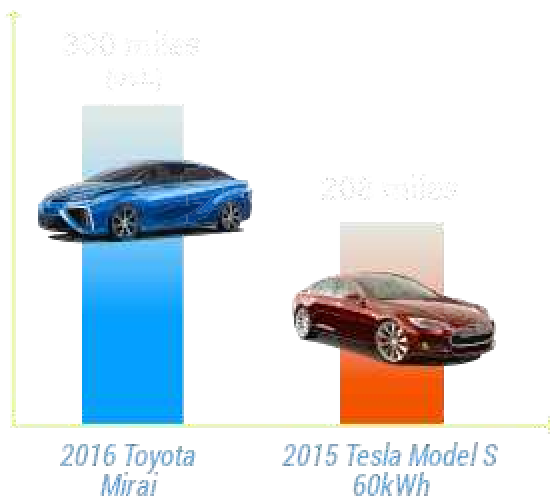
Hydrogen Costs less, is cleaner, and can be acquired from more sources than anything else:



You can fill up just like any car on Earth PLUS in many new ways

Page 5 EXHIBIT 95 – Case # 22-cv-1107-TSH, Norcal 9th District

The entire supply and creation chain can be 100% clean



Hydrogen cars beat lithium battery cars on range, weight, safety, flexibility, fire issues, and hundreds of other metrics. In fact, lithium battery cars can't beat fuel cell cars on anything

Myth #10 Fuel Cells Are "BS"

Elon Musk, with much of his personal wealth invested in lithium ion battery-electric car technology, says rival fuel cell vehicle technology is "BS."

Tesla's Elon Musk once famously quipped that fuel cells are "so BS." Considering Musk's reputation as an innovator and his success with Tesla, many people have taken this comment at face value.

However, in light of FCV range and refueling ease, and Musk's personal investment in battery electric vehicle technology, it would be a mistake to accept his criticism of fuel cells without skepticism.

NOTE: A great deal of misinformation about hydrogen fuel cell vehicles stems from an article in The New Atlantis magazine. Please note that this article is several years old (it was written in 2007). Much of what was written is no longer accurate.

This page was created by Spork Marketing and references both cited data sources and official Toyota news releases. Visit http://www.toyota.com/fuelcell/ for more information about Toyota's new FCV.

More Myths and Misconceptions

Myth: Installing a hydrogen infrastructure will be prohibitively expensive

The hydrogen transition will not need enormous investments in addition to those that the energy industry is already making. Instead, it will displace many of those investments.

It is expected that the roll-out of a hydrogen infrastructure will occur regionally over time to coincide with vehicle deployment. Yet with the adoption of hydrogen fuel cell products in early markets such as forklifts, airport baggage tugs, back-up power for telecom sites; distributed power for remote communities; and in transit buses, we are seeing a near-term demand for hydrogen.

With automotive fuel cell electric vehicles in the near term horizon, we must begin to install a hydrogen infrastructure now.

Myth: Hydrogen and fuel cells are too expensive

What do computers, cell phones, televisions, wind turbines and solar panels all have in common? People initially thought that they were too expensive when they were first developed.

As with any new technology, cost can be an issue. But, as demand increases, scientists make new breakthroughs, and companies find ways to cut costs, the price will continue to go down. So, while cost remains an issue right now, hydrogen and fuel cells have the potential to be produced for even less than current technologies.

Hydrogen Costs

Many industries already use large quantities hydrogen as a raw material in the chemical synthesis of ammonia, methanol, hydrogen peroxide, polymers, and solvents. Even oil refineries use hydrogen to remove the sulphur from crude oil. But, because hydrogen products for consumers aren't widely available, there is little economic incentive to make and sell hydrogen fuel.

When analysis's evaluate hydrogen's cost to consumers, they often forget that hydrogen can be made nearly anywhere, from any power source, including renewable energy sources. This flexibility can eliminate most or even all transportation costs. Since a large portion of the price that consumers pay for fuel is for transportation, this is significant. For example, the present price of delivered liquid hydrogen is around four times the cost of producing hydrogen.

Finally, in any cost comparison of hydrogen to other fuels, we shouldn't compare apples to oranges. It isn't meaningful to compare the price of a gallon of hydrogen to a gallon of gasoline because both fuels produce a different amount of energy. What really counts is how many cents a kilometre your fuel costs. Even at the present price of delivered liquid hydrogen, if you used hydrogen to power a fuel cell vehicle, your cost per kilometre would be the same as getting gasoline for a dollar a gallon.

Fuel Cell Costs

The costs of fuel cells will inevitably decrease because the raw materials (such as graphite, commodity metals, plastics, and composite) are inexpensive. The only material that is expensive is current catalyst, typically platinum. To overcome this, scientists are researching alternative catalysts from base metals and reducing the amount of platinum needed. Furthermore, platinum may become less expensive due to new platinum recycling systems. Despite their higher setup and development cost, fuel cells have lower maintenance costs and longer operating life.

Myth: Hydrogen is dangerous

Most fuels have high energy content and must be handled properly to be safe. Hydrogen is no different. In general, hydrogen is neither more nor less inherently hazardous than gasoline, propane, or methane. As with any fuel, safe handling depends on knowledge of its particular physical, chemical, and thermal properties and consideration of safe ways to accommodate those properties. Hydrogen, handled with this knowledge, is a safe fuel. Hydrogen has been safely produced, stored, transported, and used in

large amounts in industry by following standard practices that have been established in the past 50 years. These practices can also be emulated in non-industrial uses of hydrogen to attain the same level of routine safety.

Myth: Hydrogen caused the Hindenburg to blow up.

Actually, the cause of the fire that destroyed the German passenger airship Hindenburg in 1937 in New Jersey is still unknown. An investigation in 1990 by Addison Bain, a NASA engineer, showed that the paint coating used on the skin of the airship caused the fire. The coating contained reactive chemicals similar to solid rocket fuel. When the airship was docking in 1937, an electrical discharge ignited the skin, and the fire raced over the surface of the airship.

Myth: Commercial hydrogen can make a hydrogen bomb

It's not possible to make a hydrogen bomb with commercially available hydrogen fuel for a couple of reasons. The thermonuclear explosion from a hydrogen bomb results from a nuclear fusion reaction. Two isotopes of hydrogen – deuterium and tritium – collide at very high energy to fuse into helium nuclei, releasing tremendous amounts of energy. However, to get these rare isotopes of hydrogen to fuse requires extraordinary temperatures (hundreds of millions of degrees) supplied by a thermonuclear weapon by an atomic bomb to trigger the fusion reaction. The sheer amount of energy makes this impossible for anyone but professionals in a lab. Furthermore, commercial hydrogen gas doesn't even contain deuterium or tritium. Without these isotopes, it is impossible for ordinary hydrogen gas to produce a thermonuclear reaction under any circumstances.

Myth: Hydrogen isn't a clean fuel

Hydrogen as a fuel doesn't create any emissions when used in a fuel cell. However, it is only as clean as the energy source it's derived from. Producing hydrogen from fossil fuels does create emissions, but it is less than gasoline or diesel. It is also easier to control this pollution because the pollution is limited to the fuel production process. Hydrogen is best when produced from non-polluting renewable energy sources. Different countries will make different choices, depending on their current energy availability and future priorities.

For vehicles, according to well-to-wheels studies, hydrogen fuel cell vehicles are at least twice as efficient as gasoline vehicles, and 40% more efficient than a hybrid. Most hydrogen internal combustion engines are about 30% more efficient than their gasoline counterparts and fuel cells are

100-200% (2-3 times) more efficient.

If we continue to drive vehicles running on fossil fuels, we will continue emitting carbon dioxide into the atmosphere at an ever-growing rate. But if we drive vehicles running on hydrogen, and burn fossil fuels to make that hydrogen, we can choose to sequester the carbon emitted during production or emit it into the atmosphere. If we choose to produce hydrogen from non-polluting sources of energy, we will decrease the amount of global air pollution that we will create.

Myth: There isn't an abundant source of hydrogen fuel

Hydrogen can be made from almost any source of energy. Oil, coal, hydro power, solar power, nuclear power, geothermal power and other energy sources can all be transformed into electricity and then, by electrolysis, into hydrogen.

Contrast that with gasoline for cars. Even though people tend to talk about cars running on oil, they actually run on gasoline, which is manufactured, not found. Gasoline can only be made from oil, which we get out of the ground, as a feedstock. When we can no longer find oil at a reasonable cost, we can still make hydrogen.

Myth: In cars, hydrogen can't compete with regular gas

In many ways, hydrogen vehicles are more viable than gasoline. Vehicles that use hydrogen in an internal combustion engine are about 30% more efficient than comparable gasoline vehicles. Best of all, they produce ultra-low emissions, with no $CO2$. Fuel cells are ideally suited for cars that use electrical systems instead of hydraulics for functions such as steering and braking. These cars are two to three times more energy efficient than gas cars. Also, in a fuel cell electric vehicle, automakers can put the power train anywhere, which gives them the ultimate in design freedom.

Myth: Using renewable power to produce hydrogen wastes energy

It would be ideal if you could just plug in to your solar panel or wind generator and use that power right away. However, it's not always windy or sunny, so renewable energy projects need a storage system that provides energy whenever you we need it. Hydrogen can store energy that would otherwise go to waste.

Myth: Hydrogen and fuel cell products are still in development and we can't buy them today

Hydrogen and fuel cell products are available today. Many hydrogen fuel cells are used today in forklifts in warehouses, buses in cities, and back-up power for communications companies. Companies and governments recognize the performance, financial, environmental and health benefits. These early uses are playing a pivotal role in refining the technology and establishing infrastructure.

Scientists and companies are currently testing micro fuel cells, often called portable power, to recharge and power cell phones and laptops. These should be available in the near future.

In the next couple of years, we'll start to see new vehicles available for customers too. For example, Honda, Toyota and Mercedes-Benz currently have concept cars on the go and are all planning on releasing fuel cell cars for consumers in 2015.

Twenty Hydrogen Myths That Battery Companies and Oil Companies Spend Billions of Dollar Per Year Trying to Make You Believe:

White paper published at www.rmi.org
Download the detailed report at the links below:

http://www.rmi.org/Knowledge-Center/Library/E03-05_TwentyHydrogenMyths

http://www.rmi.org/cms/Download.aspx?id=6667&file=E03-05_20HydrogenMyths.pdf&title=Twenty+Hydrogen+Myths

This peer-reviewed white paper offers both lay and technical readers a documented primer on basic hydrogen facts, weighs competing opinions, and corrects twenty widespread misconceptions. Some of these falsehoods include the following: "a hydrogen industry would need to be developed from scratch; hydrogen is too dangerous for common use; making hydrogen uses more energy than it yields; we lack a mechanism to store hydrogen in cars; and hydrogen is too expensive to compete with gasoline". This paper explains why the rapidly growing engagement of business, civil society, and government in devising and achieving a transition to a hydrogen economy is warranted and, if properly done, could yield important national and global benefits.

Abstract

Recent public interest in hydrogen has elicited a great deal of conflicting, confusing, and often ill-informed commentary. This peer-reviewed white paper offers both lay and technical readers, particularly in the United States, a documented primer on basic hydrogen facts, weighs competing opinions, and corrects twenty widespread misconceptions. **It explains why the rapidly growing engagement of business, civil society, and government in devising and achieving a transition to a hydrogen economy is warranted and, if properly done, could yield important national and global benefits.**

About the author

Physicist Amory Lovins is cofounder and CEO of Rocky Mountain Institute (www.rmi.org) and Chairman of Hypercar, Inc. (www.hypercar.com), RMI's fourth for-profit spinoff (in which, to declare an interest, he holds minor equity options). Published in 28 books and hundreds of papers, his work has been recognized by the "Alternative Nobel," Onassis, Nissan, Shingo, and Mitchell Prizes, a MacArthur Fellowship, the Happold Medal, eight honorary doctorates, and the Heinz, Lindbergh, World Technology, and "Hero for the Planet" Awards. He has advised industry and government worldwide on energy, resources, environment, development, and security for the past three decades.

About the publisher

Rocky Mountain Institute is an independent, entrepreneurial, nonprofit applied research center founded in 1982. Its ~50 staff foster the efficient and restorative use of resources to make the world secure, just, prosperous, and life-sustaining. The majority of its ~$7-million annual revenue is earned by

consultancy, chiefly for the private sector; the rest comes from foundation grants and private gifts. Much of the context of its work is summarized in Natural Capitalism (www.natcap.org). Donations are welcome and tax-deductible (#74-2244146). RMI is at 1739 Snowmass Creek Road, Snowmass, CO 81654, phone + 1 970 927-3851

Twenty myths

Myth #1. A whole hydrogen industry would need to be developed from scratch.

Myth #2. Hydrogen is too dangerous, explosive, or "volatile" for common use as a fuel.

Myth #3. Making hydrogen uses more energy than it yields, so it's prohibitively inefficient

Myth #4. Delivering hydrogen to users would consume most of the energy it contains...

...Myth #17. A viable hydrogen transition would take 30–50 years or more to complete, and hardly anything worthwhile could be done sooner than 20 years

http://www.rmi.org/Knowledge-Center/Library/E03-05_TwentyHydrogenMyths

Full document (PDF)
http://www.rmi.org/cms/Download.aspx?id=6667&file=E03-05_20HydrogenMyths.pdf&title=Twenty+Hydrogen+Myths

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abc NEWS

THE INFLUENCE GAME: Toyota's Powerful DC Friends

THE INFLUENCE GAME: Toyota has friends in high places in Washington, but are they enough?

By SHARON THEIMER

The Associated Press

WASHINGTON

The lawmakers now investigating Toyota's recall include a senator who was so eager to lure the Japanese automaker to his state that he tramped along through fields as its executives scouted plant sites, and a congresswoman who owes much of her wealth to a Toyota supplier.

Twenty Hydrogen Myths

AMORY B. LOVINS, CEO, ROCKY MOUNTAIN INSTITUTE
20 June 2003

Hydrogen technologies are maturing. The world's existing hydrogen industry is starting to be recognized as big — producing one-fourth as much volume of gas each year as the global natural-gas industry. Industry, government, and civil society are becoming seriously engaged in designing a transition from refined petroleum products, natural gas, and electricity to hydrogen as the dominant way to carry, store, and deliver useful energy. New transitional paths are emerging, some with a vision across sectoral or disciplinary boundaries that makes them harder for specialists to grasp. Naturally, there's rising speculation about winners, losers, and hidden agendas. And as the novel hydrogen concept is overlain onto longstanding and rancorous debates about traditional energy policy, constituencies are realigning in unexpected ways.

In short, the customary wave of confusion is spreading across the country. What's this all about? Is hydrogen energy really a good idea? Is it just a way for incumbent industries to reinforce their dominance, or could it be a new, different, and hopeful melding of innovation with competition? Is it a panacea for humanity's energy predicament, or a misleading *deus ex machina* destined to inflict public disappointment and cynicism, or neither, or both?

The conversation about hydrogen is confused but hardly fanciful. The chairs of eight major oil and car companies have said the world is entering the oil endgame and the start of the Hydrogen Era. Royal Dutch/Shell's planning scenarios in 2001 envisaged a radical, China-led leapfrog to hydrogen (already underway): hydrogen would fuel a fourth of the vehicle fleet in the industrialized countries by 2025, when world oil use, stagnant meanwhile, would start to fall. President Bush's 2003 State of the Union message emphasized the commitment he'd announced a year earlier to develop hydrogen-fuel-cell cars (FreedomCAR).

Yet many diverse authors have lately criticized hydrogen energy, some severely.[1–12] Some call it a smokescreen to hide White House opposition to promptly raising car efficiency using conventional technology, or fear that working on hydrogen would divert effort from renewable energy sources. Some are skeptical of hydrogen because the President endorsed it, others because environmentalists did. Many wonder where the hydrogen will come from, and note that it's only as clean and abundant as the energy sources from which it's made. Most of the critiques reflect errors meriting a tutorial on basic hydrogen facts; hence this paper.

Introductory facts

To establish a common factual basis for exploring prevalent myths about hydrogen, let's start with six points that are universally accepted by hydrogen experts but not always articulated:

- Hydrogen makes up about 75% of the known universe, but is not an energy *source* like oil, coal, wind, or sun.[13] Rather, it is an energy *carrier* like electricity or gasoline — a way of transporting useful energy to users. Hydrogen is an especially versatile carrier be-

cause like oil and gas, but unlike electricity, it can be stored in large amounts (albeit often at higher storage cost than hydrocarbons), and can be made from almost any energy source and used to provide almost any energy service. Like electricity, hydrogen is an extremely high-quality form of energy, and can be so readily converted to electricity and back that fuel-cell pioneer Geoffrey Ballard suggests they be thought of together as a fungible commodity he calls "Hydricity™."

- The reason hydrogen isn't an energy *source* is that it's almost never found by itself, the way oil and gas are. Instead, it must first be freed from chemical compounds in which it's bound up. There are broadly three ways to liberate hydrogen: using heat and catalysts to "reform" hydrocarbons or carbohydrates, or electricity to split ("electrolyze") water, or experimental processes, based typically on sunlight, plasma discharge, or microorganisms.[14] All devices that produce hydrogen on a small scale, at or near the customer, are collectively called "hydrogen appliances" to distinguish them from traditional large-scale industrial production.
- Fossil-fuel molecules are combinations of carbon, hydrogen, and various other atoms. Roughly two-thirds of the fossil-fuel atoms burned in the world today are hydrogen. (However, hydrogen yields a smaller share of fossil-fuel energy, because its chemical bonds are weaker than carbon's.) The debate is about whether combusting the last third of the fossil fuel — the carbon — is necessary; whether it might be cheaper and more attractive not to burn that carbon, but only to use the hydrogen; and to what degree that hydrogen should be replaced by hydrogen made with renewable energy sources.
- Using hydrogen as a fuel, rather than burning fossil fuels directly, yields only water[15] (and perhaps traces of nitrogen oxides if used in a high-temperature process). This can reduce pollution and climate change, depending on the source of the hydrogen. But when journalists write that hydrogen can "clean the air,"[16] that's shorthand for keeping pollutants out of the air, not removing those already there.
- Hydrogen is the lightest element and molecule. Molecular hydrogen (two hydrogen atoms, H_2) is eight times lighter than natural gas. Per unit of energy contained, it weighs 64% less than gasoline or 61% less than natural gas: 1 kilogram (2.2 lb) of hydrogen has about the same energy as 1 U.S. gallon of gasoline, which weighs not 2.2 but 6.2 pounds.[17] But the flip side of lightness is bulk. Per unit of *volume*, hydrogen gas contains only 30% as much energy as natural gas, both at atmospheric pressure. Even when hydrogen is compressed to 170 times atmospheric pressure (170 bar), it contains only 6% as much energy as the same volume of gasoline. Hydrogen is thus most advantageous where lightness is worth more than compactness, as is often true for mobility fuels.
- One of the biggest challenges of judging hydrogen's potential is how to compare it fairly and consistently with other energy carriers. Fossil fuels are traditionally measured in cost, volume, or mass per unit of *energy content*.[18] That's valid only if the fuels being compared are all used in similar devices and at similar efficiencies, so all yield about the same amount of energy service. But that's not valid for hydrogen. Fuel cells (explained further in Myth #6) are not subject to the same thermodynamic limits as fuel-driven engines, because they're electrochemical devices, not heat engines. A hydrogen fuel-cell car can therefore convert hydrogen energy into motion about 2–3 times as efficiently as a normal car converts gasoline energy into motion: depending on how it's designed and run, a good fuel-cell system is about 50–70% efficient, hydrogen-to-electricity,[19] while a typical car engine's efficiency from gasoline to output shaft averages only about 15–17%

efficient.[20] (Both systems then incur further minor losses to drive the wheels.) This means you can drive several times as far on a gallon-equivalent (in energy content) of hydrogen in a fuel-cell car as on a gallon of gasoline in an engine-driven car. Conversely, hydrogen costing several times as much as gasoline per unit of *energy contained* can thus cost the same *per mile* driven. Since you buy automotive fuel to get miles, not energy, ignoring such differences in end-use efficiency is a serious distortion, and accounts for much of the misinformation being published about hydrogen's high cost. Hydrogen's advantage in cars is especially large because cars run mainly at low loads, where fuel cells are most efficient and engines are least efficient.[21] (Hydrogen can also have other economic or functional advantages that go beyond its efficient use. For example, when hydrogen fuel cells power digital loads in buildings, hydrogen may yield even greater extra value because suitably designed arrays of fuel cells can be exceptionally reliable and can yield the high-quality power that computers need.[22])

To reinforce this sixth point, the U.S. Department of Energy (DOE) says bulk hydrogen made and consumed onsite costs about $0.71/kg. [23] That's equivalent in *energy* content to $0.72 per gallon of gasoline.[24] But *per mile driven* — which is the objective — it's equivalent to about one-third to one-half that price, *i.e.*, to about $0.24–0.36/gallon-equivalent, because of the 2–3-fold greater efficiency of a hydrogen fuel cell than a gasoline engine in running a car. Of course, the *price* of hydrogen *delivered* into the car's fuel tank will be much higher. For example, DOE says the delivered price of industrial liquid hydrogen is about $2.2–3.1/kg. If it could be delivered into the tank of a car for the same price, it would be roughly equivalent *per mile* to $1-a-gallon gasoline. Thus it can cost several times as much to deliver liquid hydrogen as to produce it. (Fortunately, as we'll see, gaseous hydrogen can be produced at a filling station and put into the car for well under $2/kg.) Price also depends on hydrogen purity. So to assess hydrogen's price or cost or value or benefit meaningfully, we need to know how it'll be used, whether it's pure enough for the task, whether it's delivered to the task, and how much of the desired work it actually does.

Different questions yield different answers

So much for the basics. What's different about Rocky Mountain Institute's perspective that underlies this paper?

- RMI believes that radical but practical and advantageous efficiency improvements at three levels — vehicles, energy distribution, and overall energy infrastructure — can make the hydrogen transition rapid and profitable.
- At least for the next decade or two, RMI envisions a distributed model for hydrogen production and delivery that integrates the gas, electricity, building, and mobility infrastructures. Instead of building a costly new distribution infrastructure for hydrogen, we'd use excess capacity inherent in the existing gas and electricity distribution infrastructures, then make the hydrogen locally so it requires little or no further distribution. Only after this decentralized approach had built up a large hydrogen market in buildings and vehicles could centralized hydrogen production merit much investment, except in special circumstances.

- RMI's insights into the full economic value of distributed power suggest that hydrogen fuel cells *today* can economically displace less efficient central resources for delivering electricity, paving the way for hydrogen use to spread rapidly, financed by its own revenues.
- RMI recognizes that especially in North America, natural gas is logically the main near-term fuel to launch the hydrogen transition, along with cost-effective renewables. If making hydrogen requires more natural gas (which it may not — see Myth #12), it should come first from natural gas saved by making existing applications more efficient. In the longer run, more mature and diverse renewables will play an important and ultimately a dominant role. Even during the initial, mainly fossil-fueled, stages of the hydrogen transition, carbon emissions will be much smaller than today's emissions from burning those fossil fuels directly. In time, those carbon emissions will approach zero. Insisting that they *start* at zero — that hydrogen be made solely from renewable energy sources, starting now — is making the perfect the enemy of the good. But done right, the hydrogen transition will actually make renewable energy more competitive and speed its adoption.

And what "headlines" will emerge from this perspective in the following discussion?

- **The oft-described technical obstacles to a hydrogen economy — storage, safety, and the cost of the hydrogen and its distribution infrastructure — have already been sufficiently resolved to support rapid deployment starting now. No technological breakthroughs are needed, although many will probably continue to occur. Until volume manufacturing of fuel cells starts in the next few years, even costly handmade or pilot-produced versions can already compete in substantial entry markets. Automotive use of fuel cells can flourish many years sooner if automakers adopt recent advances in crashworthy, cost-competitive ultralight autobodies. If fuel cells prove difficult to commercialize or hydrogen's benefits are desired sooner, there might even be a transitional role for hydrogen-fueled engine-hybrid vehicles.**
- **The hydrogen transition should not need enormous investments in addition to those that the energy industries are already making. Instead, it will displace many of those investments. Hydrogen deployment may well need *less* net capital than business-as-usual, and should be largely self-financing from its revenues.**
- **A well-designed hydrogen transition will also use little more, no more, or quite possibly *less* natural gas than business-as-usual.**
- **A rapid hydrogen transition will probably be *more* profitable than business-as-usual for oil and car companies, and can quickly differentiate the business performance of early adopters.**
- **Most of the hydrogen needed to displace the world's gasoline is already being produced for other purposes, including making gasoline. A hydrogen industry big enough to displace all gasoline, while sustaining the other industrial processes that now use hydrogen, would be only severalfold bigger than the mature hydrogen industry that exists today, although initially it will probably rely mainly on smaller units of production, nearer to their customers, to avoid big distribution costs.**
- **A poorly designed hydrogen transition could cause environmental problems, but a well-designed one can resolve most of the environmental problems of the current fossil-fuel system without making new ones, and can greatly enhance security.**

Now for the currently prevalent hydrogen myths, and what their correction implies about desirable courses of action. Writing for a mainly U.S. audience, we'll use a mixture of U.S. and international units of measurement.

Twenty myths

Myth #1. A whole hydrogen industry would need to be developed from scratch.

Producing hydrogen is already a large and mature global industry, using at least 5% of U.S. natural gas output. Globally, about 50 million metric tons of hydrogen is made for industrial use each year. That's over half a trillion cubic meters measured at atmospheric pressure.[25] The U.S. Department of Energy (DOE) reports[26] that about 48% of global hydrogen production is reformed from natural gas, 30% from oil, and 18% from coal (chiefly in China and South Africa for producing nitrogen fertilizer; half the world's hydrogen goes into ammonia-based fertilizer). Only 4% of the world's hydrogen comes from electrolysis, because that process can compete with reforming fossil fuels only under three main conditions: with very cheap electricity, generally well under 2¢/kWh (see Myth #9 below); if the hydrogen is a byproduct (about 2%, for example, is unintentionally made during "chloralkali" electrolytic chlorine production); or perhaps if the producer is charged for carbon emissions and has a carbon-free source of electricity but no way to sequester (keep out of the atmosphere) carbon released from reforming fossil fuels.

U.S. hydrogen production is at least one-fifth and probably nearer one-third of the world total,[27] is equivalent to ~1.8% of total U.S. energy consumption, and comes ~95% from natural gas at ~99% purity from steam reforming and associated cleanup processing.[28] Roughly 47% of U.S. or 37–45% of world hydrogen production is reportedly used in refineries;[29] it is made onsite, mostly by steam reforming of gas or oil, and is used mainly to make gasoline and diesel fuel. Most hydrogen production by refineries is deliberate, used to make hydrogen-rich refined products or to remove sulfur from them; some is a byproduct of making aromatic compounds. The rest of the world's hydrogen output goes to ammonia fertilizer, methanol, petrochemicals, edible fats and oils, metal production, microchips, and other products, and a little to special industrial furnaces. World hydrogen production is reportedly doubling about every decade, driven by refineries' need to make lower-sulfur fuels and by other growth industries. Usage for fertilizer has been relatively flat for the past decade, and usage for methanol is growing more slowly (roughly with GDP) as prospects fade for wide use of methanol-derived MTBE gasoline additive, so the biggest growth market for industrial hydrogen appears to be refineries.

The industrial infrastructure for centralized hydrogen production already exists. Throughout industry, most hydrogen is currently made at large plants and is used at the industrial site or nearby. There are ~1,500 km (~930 miles) of special hydrogen pipelines (720 km or 446 miles in North America) operating at up to 100 bar.[30] Moving hydrogen gas through pipelines takes about half as much of its energy as is currently lost when transporting electricity, and the pipeline is far smaller — a 1.7-meter-diameter hydrogen pipeline at 70 bar delivers 16 GW, whereas a 60-meter-tall pylon with three pairs of ±500-kVDC power lines delivers only 9 GW.[31] Hydrogen is less dense and takes more compressor energy than natural gas, but also flows better, so transporting hydrogen through existing natural-gas pipelines would deliver only ~20–25% less en-

SEE THE REST AT: http://www.rmi.org/cms/Download.aspx?id=6667&file=E03-05_20HydrogenMyths.pdf&title=Twenty+Hydrogen+Myths

MOBILE FUEL CELL PACKS VS. BATTERIES

Batteries catch on fire quite a bit and have been the result of many more fires and explosions than hydrogen. AT&T 's U-verse TV service now had a massive exploding battery problem, making it necessary for the firm to replace 17,000 backup batteries in its nationwide network.

The Federal Government has OUTLAWED Lithium Batteries on airplanes because they explode unexpectedly so often. Batteries blow up when they want to.

Fuel Cell power systems run many, many times longer and provide massively greater range per charge than batteries.

The run time of batteries constantly shortens while Fuel Cell technology does not.

Batteries have a problematic “Memory Effect” while Fuel Cell technology does not.

Fuel Cell technology is “instant-charge” via hot-swap while battery packs require hours to recharge.

Charge life- Fuel Cell systems have an extensive charge life while batteries have a much shorter end-of-life metric.

The cost per 300 mile range for a Fuel Cell technology car system is far lower than a battery system. A Fuel Cell powered car TODAY that will drive 300 miles without a refill is 50% or less of the price of a battery car that will drive 300 miles without a refill.

A Fuel Cell system can be charged from a completely clean home energy system but batteries need to be charged from a “sour-grid”.

Fuel Cell technology can make energy at home. Batteries cannot.

Fuel Cell technology has a far higher storage density than batteries.

Fuel Cell systems are far less bulky than batteries.

The weight of batteries is so great that it reduces the range of travel of a vehicle which causes the use of wasteful energy just to haul the batteries along with the car. Fuel Cell energy systems weigh far less.

The disposal of batteries, after use, presents a deadly environmental issue while Fuel Cell technology does not.

Fuel Cell technology does not self discharge like batteries.

Batteries cause a greater carbon footprint than Fuel Cell technology

Batteries require coal be burned to charge them. One pound of coal has roughly 14,000 Btu of chemical energy in it. When everything operates well, all that turns out to be generally around 30% efficient, meaning that 30% of the chemical energy that started out in the coal has become actual electricity. New H2 production systems are up to 93% efficient.

HYDROGEN TANKS VS. HYDROGEN SOLID STATE CASSETTES

Infrastructure cost per cubic foot of H2 is far more expensive with pressurized and liquefied hydrogen.

In an accident, the pressure tanks could shoot, like a rocket, through hundreds of innocent bystanders killing or

maiming most of them.

In an accident, the pressure wave from pressure tanks expels the organs of nearby people out of their bodies.

In an accident, the pressure wave from pressure tanks crushes the lungs of nearby people.

In an accident, the pressure wave from pressure tanks shoots shrapnel through the neighborhood like a hand grenade.

Ability to ship via UPS/FEDEX/US MAIL does not exist for pressurized and liquefied hydrogen but does for H2 cassettes.

Percentage of existing infrastructure that can be used for H2 cassettes is far, far greater than that which can be used for pressurized and liquefied hydrogen.

Insurance costs are far less for H2 cassettes.

Ability of tank to crush the foot of workers, thus increasing insurances costs, does not exist with H2 cassettes.

Time to refuel vehicle is only seconds for an H2 cassette while it is many times longer for pressurized and liquefied hydrogen.

Only the Fuel Cell products have the ability to be hand carried.

Only the Fuel Cell products are H2-on-Demand where H2 is not present unless needed.

Fuel Cell products have less bulkiness.

Fuel Cell products are fully scalable while tanks are not very scalable.

Fuel Cell products have better hydrogen-source-to-consumption efficiency metrics.

Fuel Cell products require no special delivery vehicles and can use any common carrier while tanks cannot.

Tanks require special pipelines while Fuel Cell technology requires no pipelines.

High pressure is required for tanks while no pressure is required for Fuel Cell technology.

Skin cutting on refueling or refilling occurs with tanks but not with Fuel Cell technology.

Your finger could freeze and snap off using liquid hydrogen but not with Fuel Cell technology.

Fuel Cell fuel is intelligent and monitors itself but tanks do not have this ability.

Fuel Cell fuel notifies you when you need more but tanks do not.

Fuel Cell fuel advises you of its health and purity but tanks do not.

The overall transport safety of Fuel Cell beats tanks by at least a magnitude.

Fuel Cell technology uses off-the-shelf, domestically available scalable components but tanks require special service safety parts.

Fuel Cell technology has fully rechargeable, recyclable, pressure variable output but tanks do not.

Fuel Cell technology use may improve insurance premiums but tanks will always increase premiums.

Factory man-power productivity increases using Fuel Cell at the plant-level over tanks

All stored H2 is live and explosive with tanks but not with Fuel Cell.

Fuel Cell increases balance-of-plant metric but tanks reduce the metrics.

Fuel Cell's source compound agnostic but tanks are fixed to source compound.

Fuel Cell is fully patent protected and tanks are not.

Fuel Cell base hardware investment is future-protected while tanks are only partially protected.

Fuel Cell technology is fully systemically modular while tanks are fixed.

Fuel Cell technology fits the box-like form factor of car while tanks dictate their location.

Tanks require an extensive safety compound required around customer storage area while Fuel Cell does not.

Tanks need an annual X-Ray and material audit while Fuel Cell technology does not.

Fuel Cell technology does not flow across the ground and surfaces in a fire like napalm like liquid hydrogen.

GASOLINE VS. HYDROGEN SOLID STATE CASSETTES

Fuel Cell technology does not flow across the ground and surfaces in a fire like napalm like gasoline.

Gasoline service stations are one of the primary sources and causes of cancer. Fuel Cell eliminates the need to go to a service station.

The gasoline and associated vapors in a vehicle while you drive cause cancer, brain damage and numerous health issues and Fuel Cell technology does not.

The residue after use of gasoline causes numerous environmental damage issues and Fuel Cell technology does not.

The residue after use of gasoline causes numerous environmental damage issues and Fuel Cell technology does not.

Gasoline is increasing in cost and hydrogen sources and end product are decreasing in cost.

Honda also announces hydrogen commitment to H2 as eventual sole fuel source:

Honda - Honda just unveiled its new hydrogen-powered car
Emits nothing but water vapour.

Just when everyone's getting all excited about electric cars usurping their fossil fuel-guzzling counterparts, Honda has announced that its hydrogen-powered cars will go on sale in Japan as early as March 2016, with launches in Europe and the US to follow.

The five-seated sedan, called the FCV Clarity, can travel 700 km (434 miles) on a single charge. It's been priced at 7.66 million yen, or US$62,807, which puts it just in the affordability range for the average consumer, the Japanese automaker saying it expects to sell far more than the 72 units it sold of its previous-generation model, the FCX Clarity. "We want this car to be the trigger for the 'hydrogen society'," Honda operating officer, Toshihiro Mibe, told Reuters at the Tokyo Motor Show in Japan this week.

A Honda hydrogen-powered car is nothing new. Back in 2008, the FCX Clarity was leased to a handful of private buyers in California as part of a subsidised trial deal, but things didn't go so well that time around.

For one thing, the car cost 10 times more than it does now, and on top of that, it was 30 percent less powerful. The hydrogen fuel cell stack was also incredibly bulky, and the last thing you want to do is

Countering the anti-hydrogen trolls

By Dan Baleen

Senators with stock market holdings in the battery industry, oil executives and Silicon Valley battery VC's spend billions of dollars to try to keep hydrogen and fuel cells from happening. U.S. Secretary of Energy Steven Chu was partners with lithium ion battery companies, so he froze fuel cells, for almost a decade, to protect his, and his friends business ventures. These abuses of public office for market manipulation, are deepky documented at such sites as: http://thesiliconcoup.weebly.com http://thesiliconcoup.wordpress.com and others.

I see some negative assumptions about hydrogen out there by these shills and paid nay-sayers. Every single one of those people, slamming hydrogen energy, and fuel cells, can be financially, and politically tracked back to competing technology companies. I believe hydrogen is the right way to go. I would like to provide some cut-and-paste of some well-known postings of others, on the Internet, which counter some of the points against H2:

“Hydrogen beats batteries, biofuel and all other vehicle power solutions”

The positions:

Hydrogen is better than batteries by many times!

Oil is the cause of cancer!

Battery makers hire writer-shills and spend tens of millions to put out hydrogen disinformation!

There is nothing better than hydrogen that anybody knows of!

Are proven by the facts below:

A. Hydrogen can be made at home and requires NO NEW INFRASTRUCTURE. You can make it for free, at home, all day long and all night long. The production can be powered by solar, wind, microbes

and other free sources. The volume of H2 produced “IS” enough to charge solid state H2 containers from Hbank, Ergenics, Fuel Cell, ECD, Horizon, JSW, Labtech, Palcan, UTC, Jadoo and hundreds of others. The metrics quoted by the anti-hydrogen crowd are just lies to protect their competing business interests.

B. It now costs less to make hydrogen from water than any known way to make gasoline and it continues to get cheaper every month: The GE Noryl system, The R4 processor and over a hundred different systems can do this NOW; with many more expected next year. The “battery shill” spin has worn thin and has been supplanted by facts. Hydrogen is made from WATER via solar energy, wind energy, microbes, radio waves, sunlight and salt, and other FREE sources of energy. Hydrogen can also be made from any organic garbage, waste, plants or ANYTHING organic via lasers, plasma beams or dozens of other powered exotics which can be run off of EITHER the grid or the free hydrogen made from solar energy, wind energy, microbes, radio waves, sunlight and salt, and other FREE sources of energy OR the grid. There is no oil that needs to be involved anywhere in the production of hydrogen. These systems trickle charge hydrogen into storage containers, either tanks or solid state cassettes, 24/7. GE, ITM Power, QSI, U of Korea and 30 others have this year announced technologies that make H2 hundreds of times more efficiently than any other energy solution.

C. Tens of millions of dollars are being spent by battery companies like A123, Cobasys, AltairNano, etc. in order to discredit hydrogen because hydrogen works better than batteries. A large number of “pundits” who act as “writers”, “bloggers”, “authors” and “non-profit evangelist group founders” are actually supported by financial gain from battery companies who are terrified of hydrogen displacing their revenue streams. They include: Ulf Bossel of the European Fuel Cell Forum, Alec Brooks, James Woolsey, EV World, Sam Thurber, Cal Cars, Felix Kramer and others.

Lets go over the battery and bio-fuel shills lies:

Anti-Hydrogen Lie # 1:
“But critics say the process of producing hydrogen requires three to four times more energy than the hydrogen later generates in the fuel cell.”
RESPONSE: This is data from the 60’s. It is now more efficient to make hydrogen than it is to make gasoline, build or use batteries or process bio-fuel. The technology has beat everything else.

Anti-Hydrogen Lie # 2:
“the cars are too expensive.”
RESPONSE: The production of hydrogen cars is at an early stage while battery cars have been around for almost a hundred years and the battery cars are still expensive for what you get. The Moore’s law on hydrogen cars shows a clear price decline to low cost in market volume. A Fuel Cell car that goes 500 miles without a charge costs half as much TODAY as a battery car that goes 500 miles without a charge.

Anti-Hydrogen Lie #3:
“ hydrogen molecules can't be contained easily without energy-consuming compressors or maintaining them in liquid form at extremely low temperatures , and it's extremely difficult to store,"
RESPONSE: This data is also from the 60’s. Hydrogen is stored in chemical powders and muds that easily contain vast amounts of hydrogen. Pressure and liquid tanks to store hydrogen are old school archaic technologies. Hydrogen can be easily stored in over 2800 different solid state compounds.

Anti-Hydrogen Lie #4:
"The infrastructure isn't there"
RESPONSE: Solid state hydrogen can be shipped by UPS, Common Carrier and uses all existing infrastructure. DOPT has already licensed and approved such solid state delivery via common EXISTING INFRASTRUCTURE. This method can reavch every person on earth TODAY! This requires almost NO NEW INFRASTRUCTURE. NO INFRASTRUCTURE IS NEEDED!!! This is the biggest lie of all. A large number of start-ups have solid state hydrogen solutions that entirely use existing infrastructure.

Anti-Hydrogen Lie #5:
"the hydrogen is too expensive"
RESPONSE: Hydrogen can be made at home or office in numerous ways powered by solar or wind or microbes or any number of free power sources. It is always being made by such devices and constantly trickle charged into solid state storage systems all day and night FOR FREE without grid power. Hydrogen processors now make hydrogen with 91% efficiency.

Anti-Hydrogen Lie #6:
"Hydrogen is too dangerous"
RESPONSE: If the gasoline in your car blows up it will do a VAST AMOUNT more death and damage than H2 ever will. You are driving a MOLOTOV COCKTAIL. H2 on fire rapidly dissipates up an into the air. Gasoline flows all over people, cars and streets and covers all of the above with flaming death you can't easily extinguish. In 2030 oil is GONE and there is NO OTHER OPTION that can be delivered world-wide in time but H2! Biofuel only solves 2% of the problem. Batteries have failed. Nuclear is too dangerous.

Anti-Hydrogen Lie #7:
"We have enough gasoline to last forever"
RESPONSE: Gasoline/petroleum/petrochemicals have now been shown to be the number one cause of cancer, and maybe the primary cause of cancer, in the world. Besides causing global warming, lung disease and all of the other bad things that it does; the oil industry itself knows that affordable oil is gone around the year 2030. Even if it wasn't, do you really want the ROOT CAUSE OF CANCER around one day longer than it needs to be? (See the EPA report "EPA/600/S-6-87/001 Sept. 1987" as one of over 16,000 studies validating this.) Gasoline, Petroleum and the plastics made from it are the single largest cause of cancer in the world. This is a known fact, verified by thousands of studies which the oil industry counters by paying pundits to say: "Well, we just are not sure yet"

This chemical array has killed more Americans than every terrorist since the beginning of time.
The petrochemical bisphenol-a, or BPA, causes precancerous tumors and urinary tract problems and made babies reach puberty early. Every gas pump has a label on it that oil and gas causes cancer and a host of lethal medical problems. When there is an oil spill, you are not allowed on the beach because most agencies classify oil as toxic.

A study of childhook leukemia in England mapped every child with the diserase and found they all occurred in a circle, in the center of which was a gas station.

Alberta’s oil sands are one of the world’s biggest deposits of oil, but the cost of extracting that oil may be the health of the people living around them. High levels of toxic chemicals and carcinogens have been found in the water, soil, and fish downstream of the oil sands. The local health authority of Fort Chipewyan, Alberta comissioned the study in response to locals’ claims that the oil extraction projects upstream were damaging the health of citizens. Petrochemicals and their byproducts, such as dioxin, are known to cause an array of serious health problems, including cancers and endocrine disruption.Total petroleum hydrocarbons (TPH) is a term used to describe a large family of several hundred chemical compounds that originally come from crude oil. Crude oil is used to make petroleum products, which can contaminate the environment. Because there are so many different chemicals in crude oil and in other petroleum products, it is not practical to measure each one separately. However, it is useful to measure the total amount of TPH at a site.TPH is a mixture of chemicals, but they are all made mainly from hydrogen and carbon, called hydrocarbons. Scientists divide TPH into groups of petroleum hydrocarbons that act alike in soil or water. These groups are called petroleum hydrocarbon fractions. Each fraction contains many individual chemicals.

Some chemicals that may be found in TPH are hexane, jet fuels, mineral oils, benzene, toluene, xylenes, naphthalene, and fluorene, as well as other petroleum products and gasoline components. However, it is likely that samples of TPH will contain only some, or a mixture, of these chemicals. The International Agency for Research on Cancer (IARC) has determined that one TPH compound (benzene) is carcinogenic to humans. IARC has determined that other TPH compounds (benzo[a]pyrene and gasoline) are carcinogenic to humans.

Benzene causes leukemia. Benzene as a cause of leukemia had documented since 1928 (1 p. 7-9). In 1948, the American Petroleum Institute officially reported a link between this solvent used in many of their industries used and cases of leukemia in their workers. Their findings concluded that the only safe level of benzene exposure is no exposure at all (2).

The largest breast cancer incidents are in Marin County, California which is tied to the air, water and ecosphere of the Chevron Oil refinery right next door. Gasoline, Petroleum and the plastics made from it are the single largest cause of cancer in the world. This is a known fact, verified by thousands of studies which the oil industry counters by paying pundits to say: "Well, we just are not sure yet"

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Benzene causes leukemia. Benzene as a cause of leukemia had documented since 1928 (1 p. 7-9). In A “fuel cell car” and an “electric car” ARE THE SAME THING. The shills want you to think otherwise. The only difference is where the electricity is stored. You can pull the batteries out of every Zenn, Tesla, Zap, EV1, Venture Vehicle, etc. and pop a fuel cell/hydrogen pack in the same hole and go further, more efficiently in EVERY SINGLE CASE.

A modern fuel cell and hydrogen system beats batteries on every front

The charge-keeping capability of a typical lithium-ion battery degrades steadily over time and with use. After only one or two years of use, the runtime of a laptop or cell phone battery is reduced to the point where the user experience is significantly impacted. For example, the runtime of a typical 4-hour laptop battery drops to only about 2.5 hours after 3,000 hours of use. By contrast, the latest fuel cells continue to deliver nearly their original levels of runtime well past the 2,000 and 3,000 hour marks and are still going strong at 5,000+ hours

The electrical capacity of batteries has not kept up with the increasing power consumption of electronic devices. Features such as W-LAN, higher CPU speed, "always-on", large and bright displays and many others are important for the user but severely limited by today`s battery life. Lithium ion batteries, and lithium-polymer batteries have almost reached fundamental limits. A laptop playing a DVD today has a runtime of just above one hour on one battery pack, which is clearly not acceptable.

Batteries require coal be burned to charge them. One pound of coal has roughly 14,000 Btu of chemical energy in it. Any reference textbook says that. When that pound is burned in an electric powerplant, steam is made, which drives turbines at high speed, alternators are turned, and electricity is made. When everything operates well, all that turns out to be generally around 30% efficient, meaning that 30% of the chemical energy that started out in the coal has become actual electricity.

(The other 70% all becomes various forms of heat, all of which contributes toward Global Warming and other problems). Now we have around 4200 Btus of remaining energy, now as electricity, which is a little over a kilowatt-hour. (It turns out that nuclear power is slightly better, at around 32% efficiency, and petroleum and natural gas turbines tend to be around 28% or 29%, but all are essentially the same.)

That electricity then has to travel long distances through transformers and wires to get to your house. If you lived right next door to a power plant, it would be fine, but for average Americans, it turns out that around 60% of the electricity put into those wires and transformers never gets to the customers at the other end! It is mostly wasted because the wires become hot because of all the electrical current flowing through them, and they act a lot like giant toasters! People are therefore not generally aware that **only around 13% of the chemical energy burned in the coal in the power plant is actually available as electricity in your house!** (The rest, the other 87% all winds up being various forms of heat, all contributing to global warming!)

So, for a pound of coal burned, your house electrical outlets then receive around 1,820 Btu of electrical power. Around 1100 Btu of that can actually get put in the batteries, due to efficiencies of battery chargers and batteries. Of the energy STORED in the batteries, the efficiencies of batteries, motors and gear trains are such that around 450 Btu of that are eventually available at the wheels as motive power. (Remember that this is out of 14,000 Btu of chemical energy that was produced when that pound of coal was burned!)

One watt-hour is equal to about 3.412 Btus, so this 450 Btus is the same as around 130 watt-hours, or, for a 14-volt automotive battery, around 10 ampere-hours of actual usable power. The 130 watt-hours is also equal to around 0.18 horsepower for an hour. Now, this might sound like a lot, but remember that the 14,000 Btu in the pound of coal resulted in this 450 Btu that is actually usable in a car, only about 3% overall efficiency! And the other 97% of that energy when the coal was burned all went toward heating that contributes to global warming.

In contrast, a gallon of gasoline has around 126,000 Btu of energy in it, of which a modern car converts around 21% into motive power, so there results around 26,000 Btu of motive power. **POINT: Around 60 pounds of coal (with 840,000 Btu of chemical energy in it) must actually get burned to provide the electricity such that a battery-powered car can do the equivalent to a single gallon of gasoline!** (60 * 450 = 27,000) (This is a VERY "losing proposition"!)

That amount of electricity that needs to go INTO the batteries in the car (to be equivalent to that ONE gallon of gasoline) is therefore the 1100 Btu per pound of coal divided by that 3.412 times 60 pounds, or around 20,000 watt-hours of electricity. That is a LOT of electricity! Say you will have 10 hours at night for the batteries to recharge. That means that you would have to have 2,000 watts of power constantly being used and feeding the batteries. For the 14 volt circuitry of standard batteries, that would mean that around 140 amperes of charging electricity would constantly be needed. (NOT the 6 amperes of a good battery charger!) (This huge charging current might actually cause the batteries to explode, unless they are a special and more expensive Deep-Discharge type of battery!) (Batteries in golf-carts are generally wired in series to reduce the amount of current needed.)

Even the house wiring involved might be in question! We are talking about a REALLY impressive battery charger, of course, akin to 25 conventional battery chargers used together, which requires that 1820 / 3.412 * 60 or about 32,000 watt-hours of input electricity. Over our ten hours, we are therefore talking about needing 3,200 watts of electricity constantly coming in to supply your battery charger. Your house electrical service is sufficient for this need, but standard house wiring would not be. If at 120 volts, a constant 30 amperes of house electricity would be needed, where normal house circuits are either 15 amp or 20 amp if heavy duty. This probably means you would need the specialized wiring like was installed for your air conditioner, which uses roughly the same amount of electricity, through a

special 240 volt wiring made especially for the air conditioner. This means you need around 15 amperes of input power to provide that 3,200 watts at 240 volts, or about 30 amps if it is 120 volts.

Herein could be a problem, because most houses were built with 100-ampere electrical service If the A/C is running and this battery charger and some other electrical devices, you might get close to the full capacity of the house wiring! The existing house wiring, and even the transformers up on the utility poles, are barely big enough and could overheat at that constant heavy ten-hour load! We haven't even yet considered the cost of all that electricity! When you think about a constant 10-hour long consumption of about as much electricity as your central air conditioner uses, you probably start to get the picture. But say you are in some wonderful location where electricity is still only 10 cents per kilowatt-hour. We are needing to use up 32 kilowatt-hours (to equal the vehicle performance of a single gallon of gasoline, remember), so that is 32 * 10 or $3.20 of electricity added to your house electric bill, for the equivalent to ONE gallon of gasoline! It does not initially APPEAR to cost anything, and the car merrily scoots around on its battery power. **But if and when an owner realizes that they also have to spend at least $3.20 in extra electricity for each gallon of gas not used, much of the financial argument goes away!**

You are encouraged to do research to confirm what is described above. It is all true. Did you notice the "worst part" of what is described above? I'm not even talking about the fact that you would wind up paying for at least $3.20 of house electricity to replace each $3 gallon of gasoline! In refining a gallon of gasoline, yes, significant energy is used up, although I have never been able to get a reliable figure. But certainly well under 840,000 Btu of refining energy is required to form the gallon (126,000 Btu) of gasoline. **Replace all cars with battery-powered vehicles, and we then would NEED to burn 60 pounds of coal or use 840,000 Btu of coal (or nuclear) chemical energy to produce the equivalent effect of every gallon of gasoline.** This is worse, regarding resource energy wastage, than the vehicles that are currently on the roads! (Yes, the energy is used up in a distant place, and maybe it seems possible to be able to be ignored, but that is still a really bad idea!) And virtually everything that does not contribute to the "motive power" winds up as wasted heat energy.

When those 60 pounds of coal were burned to create the needed electricity to duplicate the benefits of one gallon of gasoline, carbon dioxide is also released into the atmosphere. The coal is around 75% of bituminous coal, or 45 pounds of that. It is fairly simple to determine the amount of carbon dioxide that is created when it is oxidized. The amounts of carbon and oxygen have to be in a molal relationship of one to two. That means the weight relationship has to be 12 (the atomic weight of carbon) to (12 + 16 + 16 or 44) (the atomic weight of the molecule of CO2. This means that 44/12 or 3.67 times the weight of carbon dioxide is created, or in this case, 165 pounds, of carbon-dioxide would get released in this process. When a gallon of gasoline is burned in an automobile, it is less. A gallon of gasoline weights around 6 pounds, and it is about 83% carbon. That means that it contains nearly exactly 5 pounds of carbon in the gallon. Again using the 3.67 multiplier, we can see that only around 18 pounds of carbon-dioxide is released.

This means that global warming then would occur around 7 times as fast as now! (840,000 / 126,000 [heat]) or (165 / 18 [CO_2]). **If millions of people started driving battery-powered or Hydrogen-powered vehicles, it would therefore be a far WORSE environmental disaster than now, causing global warming to become even faster than it already is!**

The "Ethanol adventure" of using 1/5 of the total farm crop production of 2006 for conversion to

Ethanol, which provided only around 2% of the vehicle fuels we used in 2006, is simply endangering our near-term food supplies. News reports are already (April 2007) discussing higher milk, bread, beef, and many other food prices in our grocery stores, as a result of the massive focus on producing Ethanol. But some weather problem is bound to occur. Where we used to have massive over-production of nearly all crops, our government has planted the seeds of a true food-supply disaster, which could happen any year now. In 2008, it is expected that the amount of America's total crop production which will go to making Ethanol will be 1/3 of everything grown! It is as if we are totally crazy, or that we do not even give any thought to what might be a consequence next week or next month or next year! It really is amazing!

What are called Hybrid vehicles are promoted and sold everywhere already, cars that include both a gasoline-powered engine and a battery-powered electric motor. The promotions for them are unbelievably misleading to the public! They totally ignore all that electricity needed to charge the batteries, but then use the charged batteries to help it get very high fuel-efficiency numbers! People are buying such vehicles (which cost a premium because of their having to include two entirely separate sources of power) greatly because they are told they are GREEN and that they see those very impressive mileage numbers. Those are both very clearly pure lies! As to the GREEN part, we discussed above that the electric powerplant where the electricity was made necessarily produces around seven times as much carbon dioxide and heat loss as a gallon of gasoline produces directly.

As to the mileage figures, well, without recognizing that at least $3.20 of bought house electricity is needed to replace each equivalent gallon of gasoline (eliminating any actual savings), there are a LOT of other details that no one bothers to tell customers! Such as driving a Hybrid or battery-powered car at night consumes far more electricity for all the lights! Far less battery power is left to actually move the vehicle! And no one seems to mention that the battery-mode operation provides only roughly 10 horsepower maximum for the vehicle, meaning only low speeds and rather poor performance. And this deception is INTENTIONAL! TV ads for a Hybrid vehicle that has a 470 horsepower gasoline engine makes it seem that an owner can have his cake and eat it too! A driver who buys a car because it has a 470 horsepower engine is NEVER going to be satisfied with the performance during a 10-horsepower battery-powered mode of operation! There are many other drawbacks as well.

Another stupid-brilliant idea is manufacturing and selling vehicles that will only run on what is called E-85, meaning 85% Ethanol fuel. Again, if there were unlimited supplies of Ethanol, that might make sense. But when America uses up one-fifth of all its farm crop production to provide only around 2% of the amount of fuel that American drivers use up each year, it indicates scary thinking, or lack thereof. By the time the auto manufacturers fully perfect cars that they will be able to sell to run on E-85, and by the time there are enough service stations that even carry E-85 for such drivers, it is certain that some overwhelming crisis will occur (probably in a weather problem and severe shortages of food for Americans), where sanity might again briefly appear and the massive effort toward Ethanol will very suddenly end. For the few people who may wind up buying E-85 vehicles, they will merely wind up having something that might someday go into a museum, something like what happened to the Edsel automobile!

It is really sad that even supposed Regulatory Agencies of the Government have participated in this hype. A car that has a conventional engine, is likely to get the gas mileage that has long been known, somewhat UNDER what the EPA estimates say! But regarding Hybrids, they seem to have just

considered the battery-powered miles to be "free" (because no gasoline is used) and they have listed some Hybrids as having 60 miles per gallon fuel efficiency. That is technically true, if you totally ignore the cost of all that electricity needed as calculated above! If they wanted to go even farther, they could set up a really short test procedure where ONLY the batteries were even used, and then they could let the manufacturers advertise "1000 MPG" or "1,000,000 MPG" or more! The person's home electric bill would go off the charts, but they do not seem to see any reason to consider that expense!

There is an extremely heavily promoted new vehicle being presented in the news in 2007. The Tesla Sports Car certainly can show impressive acceleration. However, both the media reports and their own web-site present some information that simply violates the laws of Physics! It would be wonderful if such things were possible, even in a $92,000 car.

Unfortunately, they clearly have done the common "spin" that spokespeople seem to all use today to deceive the public. THAT is really sad. Especially since this particular product actually can probably provide pretty decent performance. Why is it always seen as necessary to be deceptive today?

Using information from their own web-site:

First, there is a small-print, very faint, and very hard to read Disclaimer at the bottom of their web-pages that notes that their vehicles have not yet passed government safety testing, and they say that their specifications might change as a result of that. (By the way, since they have not yet passed government safety tests, they are not yet street legal in any State and could therefore not yet be licensed!)

First, they say that the car can produce an absolute maximum of 185 kW of electrical power. Since 746 Watts is equal to 1 horsepower, this is equal to 185/0.746 or 248 horsepower. They state in the same sentence that that is equal to 248 peak horsepower. That is fine.

They show a graph where the available torque is basically constant over a wide range of motor speeds (which is fine), and the same graph also shows the horsepower curve that is linear, rising from 0 horsepower at 300 rpm and rising to that maximum of about 248 horsepower at maximum speed. That is also fine, and in good agreement with science.

However that information can be mathematically Integrated to determine the actual acceleration, when one also knows the vehicle weight. The web-site gives the vehicle total weight as being 2,500 pounds.

We can first calculate some more things that DO agree with their claims, to show that at least those claims are credible. Let's consider their vehicle top speed. The streamlined shape of the vehicle certainly has a Coefficient of Drag of around 0.3. The total frontal area of the vehicle is around 18 square feet. The claim is that the top speed is 120 mph, which is the same as 176 feet/second. We can simply calculate the total aerodynamic drag from this information (and the average density of air (around one slug mass per 420 cubic feet). It is $0.3 * 18 * 176^2 / 420$ or around 398 pounds of aerodynamic drag. There is also tire drag which is around another 45 pounds for that vehicle weight. The total vehicle drag is therefore around 443 pounds (at that speed). If we just multiply this drag force by the velocity (176) and divide by 550 to convert it to horsepower, we get 142 actual horsepower as being needed. Given that they indicate that their motor efficiency is around 85% to 90%, and there are mechanical efficiencies of the tires and wheels, this is in fairly good agreement with the roughly 180

horsepower claimed available from their graph at 13,000 rpm (times that efficiency factor). This confirms that the expected top speed is likely to be around what they claim. Fine here.
Let's look at their acceleration claim, of zero-to-sixty in around four seconds (which is impressively fast).

They certainly did that demonstration in what they call first gear, which has a total gear ratio (and therefore torque multiplication) of 14.3. It is easy to see from this ratio that the motor would be turning at close to its maximum revs at 60 mph, so first gear might have been provided simply to be able to show off with this impressive zero-to-sixty acceleration. In any case, they provide a torque curve for their motor, which suggests that it would produce an average of around 160 ft-lbs of torque through this whole sequence. Multiplying this by the total gear ratio gives around 2300 ft-lb of torque, which becomes around 1900 pounds of thrust after considering the various mechanical losses. We have the aerodynamic drag of around 40 pounds average and the tire drag of another 40 pounds to subtract, so we have around 1820 net pounds of thrust available for acceleration. We divide this by the vehicle weight of 2500 pounds to get 0.73 to get the g-force acceleration. This is roughly 16 mph/second acceleration, or around four seconds to get from zero to sixty. This confirms that in their first gear, the acceleration they describe is realistic.

There is actually another factor involved here, regarding a flywheel effect of the motor rotor itself having to accelerate as well. Without knowing the Rotational Inertia (I) of that armature and rotor, it is not possible to calculate the reduction which must occur in this vehicle acceleration, but it must certainly be slightly less than calculated above. In other words, slightly over 4 seconds for zero-to-sixty is then realistic.

The acceleration claim also tells us something else about the Tesla! It has absolutely nothing to do with the matters at hand here, but it still seems worth noting. The acceleration they describe, of zero-to-sixty-in-around-four-seconds, means that the average acceleration is therefore around 0.73G (as indicated above.) On a dry and clean roadway, the best static coefficient of friction is around 1.0. This means that the 1820 pounds of thrust for acceleration must necessarily require roughly that amount of weight on the driving wheels, or around 1800 pounds. If one axle of a 2,500 pound car has 1,800 pounds on it, the other axle has only 700 pounds. This would be an incredibly dangerous vehicle to drive on any curvy roads, if it has that extreme of a weight-distribution. For an actual Licensed highway vehicle, it could not possibly pass road safety tests with such an extreme weight-distribution. Maybe it will be modified before any get onto the road. Which also would mean that the acceleration performance would necessarily have to be slightly less. (It is interesting all the things that Physics can tell us about any mechanism!) (They might also have used extremely sticky tires for such runs, where less vehicle weight would then have to be on the driving axle.)

So the actual mechanical performance of their car is impressive. Again, much of that is because it is a rather small car that is very aerodynamic. Still, impressive.

However, when we get to the charging of the batteries, their claims seem extremely outrageous. They claim that after driving 100 miles (presumably at highway speed) it only takes two hours to recharge the batteries, and by simply plugging it in.

If we do a drag analysis for 60 mph (similar to the 120 mph calculations shown above), we can see that the total vehicle drag is around 100 pounds aero plus 45 pounds tires or 145 pounds total. As above,

this calculates to 23 horsepower being constantly needed. To drive 100 miles at that (constant) speed takes 1.66 hours, or 38.7 horsepower-hours of energy. This is the same as around 29 kilowatt-hours of energy. However, getting electricity out of batteries is not a perfectly efficient process, and they acknowledge that their motor ranges from 90% to 80% efficient. To charge this amount in a two hour period therefore requires charging at a rate of over 15,000 watts. Their charger circuits cannot have perfect efficiency so certainly around 18,000 watts of household electricity would be needed.

If this were simply "plugged in" to a standard outlet, it would require 160 amperes at 110 volts! But standard household outlets are only rated at 15 amperes and even heavy duty ones are only rated at 20 amperes! They are talking about so much electricity that at least 6 or 8 standard outlets would be needed to provide enough power! In fact, the very special wiring that was put in your house for your central air conditioner might not be enough to provide the 80 amperes at 220 volts that would apparently be needed to charge a Tesla in the two hours as described.

In this area, their promotion is extremely misleading. It cannot simply be plugged in as they imply. Very heavy duty special house wiring is required to be able to do that massive charging.
From generally known evidence regarding charging batteries extremely fast like that, the internal structure of the battery often suffers and the battery lifetime might therefore suffer. They don't mention what the cost of replacing their battery pack is, but it certainly would be expensive. A moderately similar experimental electric car recently shown to the press has such an exotic battery pack that replacing it would cost over $300,000! Obviously, the Tesla battery pack is not that exotic or expensive, but it clearly would be a significant expense if and when it needs to be replaced.

A Tesla spokesperson was on TV talking about this after the above text was written. The battery pack would apparently currently cost around $9,000 to replace, but she pointed out that battery technology is constantly improving and that cost might drop. She also said that the battery pack lifetime is currently at least two years. It was refreshing to see an honest and open answer to such a question.
Similarly, as discussed much earlier about battery-powered vehicles, the COST of that electricity can be significant. Using Tesla's numbers and this analysis, we are talking about needing to charge around 29 kWh actually into the batteries (in those two hours, after that 100-mile drive). And that due to the efficiencies of chargers, this necessarily requires at least 35 kWh of actual house electricity. If electricity is charged at conventional rates of around 10 cents per kWh, this is around $3.50 for the electricity for that hundred miles. Granted that this is less than the cost of gasoline in any vehicle to go that distance, but it is still considerably more (around triple) what they claim the electricity cost would be.

But finally, the worst part of such an interesting vehicle is that problem described above regarding the amount of coal that would need to be burned at that remote electric powerplant to provide that much electricity. With the Tesla numbers and this 100 mile trip example, the calculations presented far above show that around 65 pounds of coal would have to be burned in that unseen electric powerplant, which would send around 240 pounds of carbon dioxide into the atmosphere, to provide the electricity for a Tesla to make that (relatively constant speed) 100 mile trip. If a small gasoline engine were used instead inside a similarly aerodynamic and light and small vehicle, maybe two gallons of gasoline would have been required to go that 100 miles, which would have released around 36 pounds of carbon dioxide into the atmosphere. Even if a full-sized sports car such as one of my Corvettes made the trip, with there highway 27 mpg, only 3.7 gallons of gasoline would be used, which would send 67 pounds of CO_2 into the atmosphere. The Tesla causes nearly four times as much carbon dioxide to be dumped

into the atmosphere than my big-gasoline-engined Corvette would!

Therefore, the Tesla, which is being promoted as being TOTALLY green, in reality causes at least four times as much carbon dioxide to be sent into the atmosphere than if it simply had a gasoline engine in it! Otherwise, it seems to be a rather attractive idea! Impressive acceleration and top speed and decent range. Only the immensity of the charging process, and the consequences of that are such terrible necessary requirements. Like discussed above, NO battery-powered vehicle has any of its own energy, and it requires to get all that energy from some different power source, in this case, house electricity. Even if Tesla is right that electric power companies would give tremendous rate reductions for the electricity because it was nearly all used at night, that cannot stop the requirement that the (remote) electric powerplant necessarily has to cause the release of that 240 pounds of carbon dioxide into the atmosphere from the coal burned.

By the way, many of the advantages of the Tesla have to do with its tiny size and very aerodynamic shape. Any car that had a more conventional size and shape would require a far, far bigger motor and far, far more electricity and battery size and capacity. If that car had a similar horsepower gasoline engine in it, the acceleration and top speed would be comparable, and the gas mileage would be impressive. The two main differences would be that the range would be easily 500 miles (with maybe an 8 gallon gas tank) and that the weight of the vehicle would be more engine instead of the same total weight of batteries.

The Tesla information is very vague about its battery system. Obviously, they are protective about their own unique advances. But we have calculated here that to charge at the rate they describe, there must be around 15,000 watts of charging that is done. Their literature mentions that their charger works at 70 amperes. This seems to imply that their batteries must be a series battery pack, because these numbers imply an effective battery voltage of around 200 volts. Such a high voltage (instead of conventional cars 12-volt batteries) makes a lot of sense in permitting far thinner wires to be used inside the car and in the charger and connectors, although even 70 amperes requires fairly stout wiring.

I suspect that you will NEVER see any reference to a Tesla being driven at night (because all those light bulbs use up a LOT of electrical power which is therefore taken away from being available for the electric motor); nor being driven with the (included) air conditioning operating. Automotive air conditioning normally takes around 6 horsepower, so the 23 required horsepower for that 60 mph highway driving would become 29 horsepower. This would both reduce the range by 25% and increase the charging time by 30% (as well as increasing the carbon dioxide given off at that distant electric powerplant by another 30%).

I realize that there are many optimistic people who simply say that the detriment of burning coal (which currently provides around 51% of all the electricity used in the US) could be eliminated by CHOOSING to use nuclear powered powerplant electricity instead. First, you don't have any way of deciding where your electricity is made, but second, few people seem to realize that the US already mined essentially all of its Uranium some years ago, and all of the 39 Uranium mines in the US have been closed and completely shut down for some years as a result. We import virtually all the Uranium used in American powerplants! No one seems to know that! (Only a very small percentage is actually from US sources, and that happens to be from the decommissioning of nuclear weapons, for just a few percent.)

There are certainly other even more optimistic people who simply assume that photovoltaic cells (solar cells or PV) can supply the needed electricity. First, such electricity is only available during the daytime when the sun is shining (and Tesla describes recharging through the night). But people who want to believe that have no clue as to how many PV cells would be needed! We have calculated above that around 18,000 watts of electricity would be needed to do the charging that Tesla describes. In a different energy-related page in this Domain, we present the Physics of PV devices, where around 7 watts per square foot of PV cells is possible during bright sunlight around noon. Even under those perfect conditions (noon, no clouds) around 2600 square feet of PV cells would be required. That web-page presentation describes that it is common that around $150 in total installed cost is involved for each square foot of PV cells. This would mean that around $390,000 worth of solar cell installation would likely be required to provide the amount of electricity the Tesla describes being needed! I suppose that if you can afford a $92,000 electric car, you may also be able to afford $390,000 of solar cells to charge it! But keep in mind that this is for NO CLOUDS and only around noon! Even more solar cells would be required for nearly any real climate!

See the problems? Even though that Tesla can show impressive acceleration and top speed, and decent range, and even though it is such a tiny car that the amount of electricity used is only around three cents per mile (while even at 50 mpg with a small gasoline engine, the gasoline would currently cost around 6 cents per mile), the bottom line regarding why it is even supposed to be desirable is allegedly how GREEN it is. But the reality is that some distant electric powerplant has to pump at least four times as much carbon dioxide into the atmosphere than if the vehicle had simply had a smaller gasoline engine. **The single point for which it is sold is therefore (sadly) totally invalid.** It may be fortunate that the only people who will be able to buy a $92,000 car probably have plenty of money available! However, I suppose that most of them will not even be bothered by the need for maybe an extra thousand dollars of specialized heavy duty wiring being installed in their house to be able to charge the Tesla. And their likely lifestyles are such that they will never even notice if their electric bills happen to get a lot higher because of charging their Tesla.

I see it as a wonderful "novelty" for rich people to play with. For the practical reasons presented in this article, it seems inconceivable that "normal" people will ever benefit from such battery-powered vehicles or even use them (except for golf carts and electric wheelchairs).

It would be nice to be able to say that there was any chance whatever that this technology could advance to actually becoming useful some day. But Tesla even notes that they have already accomplished impressive efficiencies of around 90% and 80% at peak use. What a Tesla has is probably about as good as it will ever be able to get. And if it were not for the horrible requirement that some distant electric powerplant has to release massive amounts of carbon dioxide into the atmosphere to be able to charge the Tesla, it actually could be a useful product. But when a product is SOLD and PROMOTED as being totally green, while the actual reality is entirely opposite, it then turns out to be a really terrible idea!

The truly sad thing is that if millions of people could some day drive vehicles that are electric powered like the Tesla, Global Warming would necessary become far worse as a direct result."

Such limitations have led to an enormous interest in alternative power sources, of which the fuel cell is the most promising candidate. Storage density, i.e. the electrical capacity available per unit mass of energy storage means, is one of the most important parameters.

So you have the well-known battery and competing fuel shills who are anti-hydrogen sheep: Ulf Bossel of the European Fuel Cell Forum, Alec Brooks, James Woolsey, Elon Musk, John Doerr, EV World magazine, The Fool, Sam Thurber, Cal Cars, Felix Kramer and plugin America lobby group, Think Progress, and similar...

Yet for every manipulated argument they come up with, they are shot down by hundreds of sites with facts.

The interventions of these 'doubters', shills, meat puppets and trolls fall into a number of clear categories which I'll summarise as:

1 ***"You can't succeed because no-one has ever succeeded at this (sports car making / battery-power / taking on the majors, etc etc) before"***. - May I commend to everyone Dava Sobel's wonderful (and short!) book, "Longitude", which offers a perfect map of the tendency of government and the scientific establishment collude to reject true innovation. This effect can only be overcome when a tipping-point of perceived popular utility is reached, at which point the establishment suddenly has a bout of collective amnesia about their earlier denials. (Same story many times over, historically, of course - from Gallileo onwards.)

2 ***"It's inefficient to carry around"***. Rather as it's inefficient to carry around a full tank of gas, perhaps? Or to carry around a SUV chassis which itself weighs a ton or more? (Come on, Detroit, you can find a better argument than that, surely?)

3 ***"This technology is not a solution and never will be."*** This very much reminds me of the IBM's famously short-sighted take on the prospect of home computing, back in the 70s. The language of these contributions, let alone their content, points to a thought-process rooted in volume-producers'vested interests. Consider the successes of some other new-tech challengers of vested interests: Dyson taking on Hoover with a bagless vacuum-cleaner; Bayliss bringing clockwork (i.e. battery-less) radios and laptops to the third world; thin-film solar panels (sorry, can't remember who, but you know who I mean). On this point, it was deeply depressing, at a high-level environmental science conference of the UK Government last year, for me to witness a "leading and respected" Professor of Transport rejecting electric traction out-of-hand with the words "it will never be more than just power storage on a trolley". Given that this "expert" was advising ministers of state setting future national policy on alternative transport, my immediate thought was "Who pays this man's research grant?"

You can see more about their tactics in the film: MERCHANTS OF DOUBT.

So let's be vigilant for any who claim, in a smooth way, that invention can't possibly have the answers. From a position of some expertise in this field, may I remind readers that the "you-don't-understand-how-our-industry-works" argument has been the policy instrument of choice for numerous corporate fraudsters and protectionists down the ages (Enron, anyone?). New York's energetic DA, Mr Spitzer, has made a fine career out of challenging such thinking in the finance sector (with the simple rejoinder: "WHY does your industry work like that? Against customer choice?"). And then of course there's the entire consumer movement (remember Flaming Fords? remember "Unsafe at Any Speed"?). We can and should ask the same questions of the conventional auto industry.

The good news is that genuine innovation will out - as long as ordinary consumers are able to find it and buy it. One of the early lessons of the twentyfirst century, thank goodness, is that the old-school, browbeating style of corporate communication - terrorising one's customers into rejecting alternatives - increasingly fails as people wise up to making decisions based on their own independently-gathered information about benefits and risks. (Interestingly, a popular reaction against "selling by fear" is also now happening in the political field. Now why might that be?) As a consumer, one doesn't have to agree with the in-ya-face techniques of anticorporate critics like Michael Moore and Morgan Spurlock to still subscribe to the view that we can buy what we want to buy. We no longer want to be told by old-tech that new-tech is inherently suspect. Isn't it old-tech that brought us dependency on oil, climate change, wars over energy sources?

So c'mon people, how about a reward system for "spot the spoiler"? I'm all for free debate on the issues, but some of these blogs smell rather like the work of paid old-tech corporatists trying to sabotage your success.

Challenge such interventions with the greatest possible vigour, and let consumers decide for themselves!

1.) Battery companies are spending millions of dollars to knock H2 because it works longer, better, faster and cheaper than batteries! Most of the people writing these screaming anti-H2 articles are battery company shills or have investments there. H2 does beat batteries on every front so the should be SCARED!

2.) The steel unions hate H2 because H2 cars don't use steel. Steel is too hard to afford any more so nobody will use it in any case.

3.) Activists hate H2 because they think it can only be made by the oil companies and they hate the oil companies. This is a falsehood created by the battery and steel guys.

4.) Oil companies hate H2 because it is so much better than oil but they only get to hate it unto 2030 when the affordable oil runs out. Then they know they must love it because H2 energy will be all that is left. The Oil industry is dismayed that H2 is coming on so fast and they are trying to slow it down even more.

5.) Other alternative energy interests hate it because it is getting all of the funding because the polita-nomics are better with H2 than ANYTHING ELSE ON EARTH.

If the gasoline in your car blows up it will do a VAST AMOUNT more death and damage than H2 ever will. You are driving a MOLOTOV COCKTAIL. In 2030 oil is GONE and there is NO OTHER OPTION that can be delivered world-wide in time but H2! Biofuel only solves 2% of the problem. Batteries have failed. Nuclear is too dangerous.”

The Hydrogen Economy

Fuel cells powered by hydrogen are about to hit the market. In time, they'll let us kiss the sheikhs goodbye.

FORTUNE

By David Stipp

As far back as Jules Verne, visionaries have predicted that society will someday be utterly transformed by energy based on hydrogen. The lightweight gas, the most abundant element in the universe, can be made from water. It is wondrously clean, emitting mainly pristine steam when burned. When fed into fuel cells, which generate electricity, it offers unprecedented efficiency--these electrochemical reactors extract twice as much useful energy from fuel as internal-combustion engines can.

In fact, hydrogen-powered fuel cells promise to solve just about every energy problem on the horizon. In homes and offices, fuel cells would keep the lights on when the grid can't. Cars propelled by the cells wouldn't foul the air. Hydrogen-based energy would mean less global warming as we shift away from fossil fuels.

None of this is as pie-in-the-sky as it sounds. Potent commercial forces are bringing the hydrogen economy along faster than anyone thought possible only a few years ago. In the next two years, the first wave of products based on hydrogen-powered fuel cells is expected to hit the market, including cars and buses powered by fuel cells, and compact electric generators for commercial buildings and houses. Technology for generating hydrogen is ready now: "reformers" that extract hydrogen from natural gas, and "electrolyzers," Jules Vernian devices that extract hydrogen from plain water. Those electrolyzers, if powered by so-called renewable-energy technologies like wind turbines and solar panels, could truly put an end to oil. Wind turbines and solar panels are emerging fast; after long decades of development, they have entered a Moore's law-like pattern of rapidly falling costs. All these advances add up to a startling reality. Major oil companies have begun to bet quietly but heavily on a hydrogen future. So have many of the largest manufacturers, including United Technologies, General Electric, Du Pont--and every major car company.

Like all disruptive technologies, the hydrogen revolution must overcome major barriers to achieve ubiquity, however. The greatest hurdle is cost: Fuel cells are too pricey for all but niche applications, and they're likely to remain so until economies of scale kick in. Likewise, fully installing the infrastructure needed to produce and deliver hydrogen on a massive scale--think of the refineries, pipelines, and gas stations that have been built to support the oil economy--will take decades and require tens of billions of dollars. Meanwhile, support for hydrogen technology in Washington, D.C., has been almost as evanescent as the gas: For the fiscal year ended Sept. 30, the Department of Energy's hydrogen research budget was $27 million, a minuscule 0.14% of the DOE's total budget--and earlier this year the Bush Administration proposed roughly halving that allotment.

Still, it's hard to dismiss a technology that promises a way to kiss the sheikhs goodbye. Suppose further unthinkable things happen--a fundamentalist coup in Saudi Arabia, say, or terrorist attacks on the

kingdom's brittle petroleum infrastructure, either of which might precipitate an oil crisis. Could we put the Hydrogen Age on the fast track?

Hydrogen experts, though accustomed to thinking in decades instead of years or months, are already mulling that question, and their answer can be summed up as "yes." A major source of hydrogen is instantly available: natural gas, or methane. Already it is widely processed into hydrogen for manufacturing plastics, "hydrogenated" vegetable oil, and other products. Making hydrogen this way is not totally environmentally friendly--reforming methane generates carbon dioxide, the main culprit in global warming. But it's strategically friendly: Today 99.5% of the methane consumed in America is produced in the U.S. and Canada. What's more, companies such as Praxair of Danbury, Conn., and Air Products & Chemicals of Allentown, Pa., operate a limited but widely dispersed hydrogen infrastructure in the U.S., including pipelines, storage terminals, tanker trucks, and reformers.

Such assets represent a kind of hydrogen-economy starter kit. To jump-start the transition, the first order of business would be to outfit service stations to fuel the hydrogen-powered cars that will soon reach the market, says C.E. "Sandy" Thomas, president of H2Gen Innovations, an Arlington, Va., startup developing novel low-cost methane reformers. Revving up the hydrogen economy would also probably require heavier spending, by industry or government, to accelerate the low-cost mass production of fuel cells, says John A. Turner, a principal scientist at the DOE's National Renewable Energy Laboratory in Golden, Colo. The technology faces the classic chicken-and-egg problem, he explains: To compete with piston engines and achieve mass commercialization, the costs of the technology must come down by at least a factor of ten. That can happen, but probably not without the cost savings that flow from mass production.

Short-term moves like those would pave the way to a future that excites giant oil companies and environmentalists alike--in which methane would begin to recede as a hydrogen feedstock while renewable sources, like solar and wind power, and biomass, would come to the fore. Before September's terrorist attacks such a shift was projected to happen around the middle of this century. Royal Dutch/Shell, one of the oil giants that is investing heavily in a hydrogen future, projects that by 2050 about half of the world's entire energy supply may well originate with renewables.

Around the industrialized world, the seeds of oil displacement are already visible. Next year, for instance, three major energy companies in Scandinavia plan to build a pilot plant to make hydrogen from wind power. While it's only a start, the implications are huge: Denmark, the world wind-power leader, already gets nearly 15% of its electricity from the wind. Use that electricity to produce hydrogen, and the Danes would have the energy equivalent of the euro: an energy currency that can be efficiently swapped for heat or locomotion, or turned back into electricity. And while electricity is hard to store in large quantities, hydrogen is easy. The Scandinavians plan to use it in fuel-cell-equipped buildings and vehicles--such as the hydrogen-powered buses that DaimlerChrysler expects to roll out in Europe next year.

The U.S. is rich with similar prospects. The windy Dakotas, if studded with twirling wind turbines, could become the Saudi Arabia of hydrogen. Spare megawatts from the 55 major dams along the Columbia River and its tributaries in the Pacific Northwest could be fed into electrolyzers, turning them into the equivalent of inexhaustible oil gushers. Hawaii could help too: Its volcanically abundant geothermal energy could be tapped to generate electricity for churning out hydrogen.

In a telling sign of how far renewable energy has matured since the Age of Aquarius, Home Depot

recently started selling solar photovoltaic systems made by AstroPower of Newark, Del., at some of its California stores. Meanwhile, companies such as United Solar Systems in Troy, Mich., have rolled out nifty forms of solar roofing--including shingles that can double as little power plants. Solar cells are only one-tenth as expensive today, on a per-watt basis, as they were in the 1980s, and manufacturers are having trouble keeping up with demand. Worldwide, photovoltaic sales jumped 38% last year. (No high-tech bust there.)

Despite its dropping cost, solar power is still too expensive to mount a serious challenge to grid-supplied electricity--most solar installations power buildings and machines remote from the grid, or are fostered by government-sponsored programs. But wind power, the other high-growth prospect in renewable energy, faces no such limitation.

Thanks to advances such as the advent of monster 1.65-megawatt turbines, wind-power costs have dropped 90% since 1980. In some places, wind watts are now cheaper than those from oil- or gas-fired generators. Over the past decade wind power worldwide has grown, on average, 25% a year, faster than any other energy source, says the Worldwatch Institute, a Washington, D.C., think tank. (Only solar comes close, with a 20% annual growth rate.)

Europe's wind capacity could reach a staggering 60 billion watts by 2010, enough to serve 75 million people, according to the European Wind Energy Association. (By comparison, a large nuclear plant has a capacity of about one billion watts.) The U.S. lags behind Europe in developing wind power, but America's wind-generating capacity is ramping up fast--it's expected to increase by a whopping 60% this year, or 1.5 billion watts.

Much of the growth is happening not in green-dominated California but in America's thrifty heartland. For example, five years ago a school district in Eldora, Iowa, proposed erecting a wind turbine to supply its high school with electricity. The local utility blocked the idea by refusing to allow the wind-supplied watts to offset grid power at the going rate, says Bill Grove, superintendent of the Eldora-New Providence school district. Recently, though, the utility, Alliant Energy of Madison, Wis., rethought the issue and decided to join with the district to install a turbine three times as powerful as originally planned.

Simple arithmetic has inspired a growing number of Midwestern towns, school districts, and farmers to emulate Eldora's pioneering move, says Thomas A. Wind, a wind-power consultant in Jefferson, Iowa. The systems generally pay for themselves over a decade or so, he adds, then continue to whirl out cash year after year.

Richard and Robert Kas, farmers in Woodstock, Minn., were among the first to capitalize on the trend. Two years ago they allotted six acres of their family farm to an energy firm that planted 17 wind turbines, together capable of generating up to ten megawatts, enough for some 4,000 homes. Now the brothers are about to install two 750-kilowatt turbines of their own to sell power to the local utility. Richard estimates the turbines will each generate $25,000 annually after paying for themselves over about 12 years.

Renewable energy, excluding hydropower, which currently dwarfs other renewables, provides only 2% of U.S. electricity today. But its potential is huge. The harnessable wind power in Midwestern and Western states alone could supply as much electricity during a 15-year period as all of Saudi Arabia's

vast oil reserves if they were burned in power plants, according to a federal study.

Such factoids are no longer merely the stuff of environmental confabs and engineering conventions--they are guiding boardroom decisions. Energy bellwethers such as ABB in Zurich and Enron in Houston are positioning themselves to become hydrogen sheikhs by making major investments in wind power. Meanwhile, Royal Dutch/Shell has formed a division devoted to hydrogen and a division devoted to renewables--Shell's top executives have promised to kick-start the new businesses with investments of at least $500 million by mid-decade. Britain's BP (the former British Petroleum now calls itself the "beyond petroleum" company) has made a major push into solar power--it's the No. 3 photovoltaics maker. (Sharp and Kyocera, both of Japan, are the leaders.)

Clearly, the energy industry will look a lot different two decades hence. Based increasingly on hydrogen, its big players will be more diverse and far-flung than ever. Indeed, they'll probably resemble oil producers crossed with electric utilities. The energy industry's small players will be even stranger creatures: They're likely to be people like us--when we're not using the fuel cells in our homes and cars, we'll plug them in to serve as Internet-like "micropower" nodes supplying electricity to the grid.
Fuel cells are increasingly shaping up to be the 21st century's answer to the internal-combustion engine. You'll probably be able to buy yourself a fuel cell this Christmas. By year-end, Sunbeam's Coleman Powermate unit plans to launch small, portable power modules incorporating fuel cells made by Ballard Power of Vancouver. Plug Power of Latham, N.Y., H Power of Clifton, N.J., and other companies are readying bigger fuel-cell systems designed to supply homes and small businesses with electricity and heat--many have been installed in pilot programs, and full-scale launches are expected by 2004.

In part because of California's recent electricity crisis, the please-let-there-be-light market for fuel cells is likely to skyrocket: Sales, estimated at $218 million last year, should reach $2.4 billion by 2005, according to a recent analysis by Fuel Cell Technology News, a Norwalk, Conn., newsletter.
One surprising thing about this projection is that there's already a substantial market for fuel cells. In fact, the "stationary" market for the cells has been quietly growing for years. A decade ago, International Fuel Cells, a United Technologies unit in South Windsor, Conn., introduced fuel-cell systems to supply "uninterruptible" power to buildings. Now its 200-kilowatt PC25 systems are electrifying everything from an Omaha bank to a former stable in New York City's Central Park that's used as a police station. The latter system, housed in a van-sized green box next to the old stable, enabled the city to avoid a $1.2 million power-line upgrade--office machines at the precinct house sometimes couldn't all be on at once until the fuel cell was installed in 1999.

Toward the end of this decade, fuel-cell cars should become the hydrogen economy's main driver. Indeed, the auto industry has made by far the boldest investment in the new technology. Four years ago Ford and Daimler-Benz, now DaimlerChrysler, stunned rivals by committing $750 million to a joint venture with Ballard aimed at rolling out fuel-cell cars by 2004. Not to be outdone, General Motors and Toyota teamed up in pursuit of the same goal. Honda, Renault-Nissan, Hyundai, and Volkswagen have also joined the race.

Today some $500 million to $1 billion a year is going into this automotive Manhattan Project, according to analysts. None other than Henry Ford's great-grandson Ford Chairman William Clay Ford Jr. has declared that the fuel cell will "finally end the 100-year reign of the internal-combustion engine."

The venerable piston engine won't be a pushover, though--versatile and cheap, it embodies an entire century of tinkering. Further, there's still no widely accepted way to carry lots of hydrogen around in vehicles. This problem stems from the same property that made hydrogen useful for getting early-20th-century Zeppelins aloft: It's very low-density stuff, so small amounts occupy a large volume.

Like all gases, however, hydrogen can be compressed, so one proposed solution calls for cars to carry special tanks filled with pressurized hydrogen. Such tanks already exist, but more work is needed to establish safety standards for their widespread use in vehicles. (If hydrogen makes you think of the Hindenburg, think again: A 1997 report showed that the famous Zeppelin's skin was painted with chemicals used in rocket fuel. Ignited by static electricity, the chemicals probably were the main cause of its fiery 1937 demise, not the hydrogen inside. In fact, hydrogen dissipates so rapidly outside buildings that the risk of an explosion while gassing up a fuel-cell car with the stuff is practically nil.) It's likely to be at least several years before you can buy hydrogen at the corner gas station. But if you want to gas up your fuel-cell car at home, you might use one of the highly efficient electrolyzers that Stuart Energy Systems of Toronto is developing. The hydrogen appliances would require only a garden hose (for water) and an electrical outlet to generate enough hydrogen overnight for your daily commute.

The main alternative to onboard hydrogen tanks requires that cars carry compact reformers to synthesize the gas from either gasoline or methanol (wood alcohol). Those liquid fuels wouldn't require radical changes to the corner gas station. But gasoline reformers are costly, bulky, energy consuming, and complex--and they're still at the prototype stage. Methanol, while closer to prime time and less polluting to reform into hydrogen than gasoline, is very toxic. Ingesting half a cup can kill you, and unlike gasoline, it doesn't induce vomiting when swallowed.

Given those daunting problems, why are industry statesmen like Bill Ford so sure that fuel cells will blow away the piston engine? One reason is that the cells offer an astounding 100% leap in fuel efficiency over the venerable competition. Another is that fuel-cell technology is zipping along an arc of development that promises to amplify its already compelling pluses for decades to come. The piston engine, by comparison, is a mature technology that's increasingly difficult to improve.

Despite its recent fiscal woes, DaimlerChrysler, like every other major automaker, is pouring hefty sums into the effort to launch the cars between 2003 and 2005. But they won't necessarily turn up in showrooms then. The first ones are expected to be marketed as "fleet" vehicles such as taxis. That's because corporate fleets can be gassed up at home bases and so can be rolled out before hydrogen is widely available at service stations. The fuel-cell car market probably won't surpass 5% of U.S. new-vehicle sales, now about 850,000 vehicles a year, until after 2008.

That is, unless the federal government steps in to fast-track the hydrogen economy. Doing so would require a major energy-policy rethink--but probably nothing like the extravagant spending with which the government tried to answer the oil shocks of the 1970s. Instead, seed funding, tax incentives, and mandates for electric utilities to add more renewable power would help; so would shifting federal vehicle fleets to fuel cells. Uncle Sam's hydrogen to-do list might include:

• Creating incentives to install methane reformers at 10% of the nation's service stations--the minimum deemed necessary to support initial mass commercialization of fuel-cell cars. The installations would

cost a total of $4.1 billion, according to a study last year jointly funded by the DOE and Ford Motor.

• Earmarking, say, $500 million a year through mid-decade to hurry wind, solar, and other renewable-energy technology. Tax incentives would help erect wind turbines; R&D grants might speed development of advanced "multilayer" solar cells, capable of cutting the cost of solar power in half.

• Providing $500 million to ramp up fuel-cell manufacturing. The money would fund federal R&D matching grants for labs working on fuel-cell manufacturing processes. It would also pay for shifting federal vehicle fleets to fuel-cell technology, helping fuel-cell makers more quickly achieve economies of scale.

Federal handouts for hydrogen might seem anathema to the oilman in the White House. Yet in Texas two years ago then-governor George W. Bush enacted a sweeping mandate that made Texas a leader in renewable energy. Its first phase requires the state's electric utilities to add 400 megawatts of renewable-energy generating capacity by 2003. The utilities opted for wind power; won over by its low cost, they have since doubled their renewable-energy commitment. Randall Swisher, executive director of the American Wind Energy Association, a trade group in Washington, D.C., calls the Texas program "the most effective renewable-energy policy in the country." More such mandates are sorely needed, adds Swisher, for many utilities and state power regulators still view wind power with a jaundiced eye.

Once the fuel-cell market begins to take off, its impact could snowball. Using hydrogen to combine such renewable energy sources with highly efficient fuel-cell cars could deliver a double whammy to oil's hegemony, says Amory Lovins, an influential energy expert at Rocky Mountain Institute in Snowmass, Colo. That's because the cars' fuel cells could be used both for transportation and, when parked, to generate electricity to feed into the grid. The dividends from such dual-use "Hypercars," he predicts, would probably make them less expensive to get around in than conventional gasoline-powered cars even when oil is still fairly plentiful and cheap, accelerating its displacement by hydrogen. Oil will still have a role in future years: "It will be good mainly for holding up the ground," he quips.

NBC NEWS Oct. 14, 2015

Toyota to Phase Out Gas-Powered Vehicles, Doubling Down on Hydrogen

by Paul A. Eisenstein

Toyota Motor Co. wants to virtually eliminate gasoline-powered vehicles from its fleet by 2050, and is betting that hydrogen cars, rather than electric vehicles, will be the long-term answer.

The Japanese maker recently introduced the Mirai, its first retail fuel-cell vehicle, and though sales have so far been measured in the hundreds, the target is to reach 30,000 annually by 2020, and even higher in the years beyond.

A number of other automakers are experimenting with hydrogen power; Hyundai already offers a fuel-cell version of its Tucson SUV, and Honda will launch a retail model next year.

While most competitors are focusing on hybrids, with a heavy emphasis on battery-based models, Toyota remains skeptical about the long-term role of electric vehicle technology.

Japanese auto giant Toyota Motor's hydrogen fuel-cell vehicle Mirai is displayed in Tokyo in November 2014. YOSHIKAZU TSUNO / AFP - Getty Images

LA TIMES

Carmakers prepare to shift to hydrogen fuel cells

Hyundai started leasing a hydrogen fuel cell version of its Tucson SUV, above, this year. To the right is a fuel cell stack on display at the 2013 L.A. Auto Show. (Christina House / For The Times)

By CHARLES FLEMING
contact the reporter

SHARELINES

- "Toyota actually favors fuel cells over other zero-emission vehicles," a Toyota manager says
- Toyota will launch a fuel cell sedan in Japan early next year and in the U.S. by the summer
- Honda is preparing to launch a new fuel cell car next year

OCTOBER 26, 2014, 5:00 AM

Concerned about slow sales of electric cars and plug-in hybrids, automakers are increasingly betting the future of green cars on hydrogen fuel cell technology.

Even Toyota Motor Corp., maker of the popular Prius gas-electric hybrid, will use hydrogen instead of batteries to power its next generation of green vehicles.

"Today, Toyota actually favors fuel cells over other zero-emission vehicles, like pure battery electric vehicles," said Craig Scott, the company's national manager of advanced technologies. "We would like to be still selling cars when there's no more gas. And no one is coming to our door asking us to build a new electric car."

But even hydrogen's most ardent proponents agree the technology faces enormous hurdles. Like electric cars, hydrogen fuel cell vehicles are expensive. So is the infrastructure to refuel them.

"We would like to be still selling cars when there's no more gas. And no one is coming to our door asking us to build a new electric car," said Toyota's Craig Scott. (Bob Chamberlin, Los Angeles Times)

Car companies have been slow to put hydrogen fuel cell vehicles on the market in part because of the lack of fueling stations. Operators of fueling stations, in turn, won't build more retail outlets unless they see more fuel cell car sales.

Dan Poppe is among the few early investors in hydrogen stations. Wearing a hard hat and coveralls at his Burbank hydrogen station, Poppe chews on the edges of his mustache and worries about his future.

"In 2004, we were told we'd have 10,000 cars on the road [in California] by 2009 — but it was more like 200 cars," said Poppe, whose company, H2 Frontier, builds and operates stations in California. "Today, we still only have about 250. That's not going to do it."

Hydrogen fuel cell car makers and station operators like Poppe are subsidized by the state of California, which has set a goal of having 1.5 million zero-emission cars on the road by 2025. By the same year, the state wants 15% of all new cars sold to be zero-emission vehicles.

The category includes plug-in hybrids — which can travel a few miles on battery power alone before a gas engine kicks in — but it doesn't include traditional hybrids, which sell at lower cost and in much higher volumes.

Automakers are still working on electric car technology, and sales of battery electric and plug-in hybrid vehicles are up 30% this year over 2013. Still, total sales for zero-emission vehicles represent less than 1% of all cars nationally.

They are more popular in California than anywhere else. The state's drivers own 40% of the nation's zero-emission vehicles, almost all of them plug-in hybrids and battery electric vehicles. With automakers still struggling to produce a mass-market electric car, fuel cells increasingly look like the ascendant platform.

> **"We would like to be still selling cars when there's no more gas. And no one is coming to our door asking us to build a new electric car."**
>
> — Craig Scott, Toyota's national manager of advanced technologies
>
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Hydrogen fuel cells are designed to power electric motors much the way batteries do. But instead of storing their energy in a battery pack that takes hours to recharge, the fuel-cell vehicles store hydrogen gas in an onboard tank that can be refilled in minutes, just like a gasoline tank.

The state subsidizes hydrogen-powered cars the same way it does battery-powered cars, with the same $5,000 rebate it offered buyers of electric cars in the early days. (Electric car buyers now are eligible for a $2,500 state rebate.) New fuel cell car buyers also qualify, at least until the end of 2014, for a $4,000 federal rebate — down from as much as $12,000 for cars that hit the road in earlier years.

The state will also award automakers environmental credits for building them, which they can use to comply with California clean air mandates or sell to other automakers who need the credits to comply. Automakers get more credits for fuel cell cars than most battery electrics or plug-in hybrids.

Hydrogen refueling station operators like Poppe also get money from the state and other agencies, among them the California Energy Commission, California Air Resources Board and South Coast Air Quality Management District.

Poppe received $3 million from the state to build a station in Chino. He got $500,000 from the energy commission and the air quality district to operate his station in Burbank.

The district says it has spent $11.4 million so far on the construction, operation and maintenance of nine Southern California stations, with "considerably more funds" having been spent by the energy commission and the air resources board, agency spokesman Sam Atwood said.

To qualify for a $1-million grant, Poppe had to invest $250,000 to $300,000 of his own money. To receive grants to cover operational expenses, he has had to hit specific performance goals — a certain number of pumps open, operating at certain capacities, by certain dates — or face being disqualified.

Sally Poppe demonstrates filling her vehicle at a hydrogen fuel station in Burbank operated by her husband, Dan Poppe, an early investor in such stations. (Anne Cusack, Los Angeles Times)

Despite the risks to entrepreneurs, Poppe believes the future is hydrogen, because fuel cell vehicles address the two main shortcomings of today's battery-powered cars: short driving range and long recharging times.

Car companies agree.

Toyota will launch a fuel cell sedan in Japan early next year and in the U.S. by the summer. Hyundai Motor Co. started leasing a hydrogen fuel cell version of its Tucson sport utility vehicle this year. Honda Motor Co., which has spent years testing and leasing its FCX Clarity fuel cell vehicle, is preparing to launch a new fuel cell car sometime next year.

Ford Motor Co., which has put 1.3 million test miles on a fleet of 300 fuel cell vehicles over the last several years, recently cut a deal with Daimler, Renault and Nissan to develop a joint fuel cell technology that all four companies would share.

General Motors Co., which holds more patents for hydrogen fuel cell technology than any other carmaker, has similarly tested its HydroGen4 car. GM has partnered with Honda, its rival for the number of new fuel cell patents each year, to co-develop new automotive fuel cell applications.

The cars, when they arrive, won't come cheap. Toyota hasn't set a price for its car here, but when it's launched in Japan it will have a $68,000 sticker price — though buyers will qualify for a $20,000 government rebate.

Fuel cell cars have about the same range as many gas-powered vehicles — as much as 300 miles between fueling stops.

Most electric cars have a range of about 80 miles, though more expensive battery-powered cars — namely, the Tesla Model S — offer more than 200 miles of driving range. The Tesla Model S starts at $72,000 and can cost upward of $100,000 with the largest battery and luxury options.

In addition, fuel cell advocates point out that there are multiple sources of hydrogen, including hydro-electric or wind generators, nuclear power plants and natural gas.

Elon Musk, chairman of the battery-electric vehicle manufacturer Tesla Motors Inc., derides hydrogen-powered cars and calls the science behind them overcomplicated.

"I usually call them 'fool cells,'" Musk told shareholders in June, having earlier dismissed the technology as "a load of rubbish."

Musk did not elaborate on specific weaknesses of hydrogen power or why he believes batteries will remain the dominant power source for zero-emission cars. A Tesla spokesperson declined requests for interviews with Musk or other executives.

Some observers caution that the appearance of competing technologies can be misleading. They say the need for clean transportation won't necessarily be found in a single system.

"If you have a fuel cell car, you have a longer range between visits to the gas station; but if you plug in at home, you never have to go to the gas station at all," said Don Anair of the Union of Concerned Scientists. "It's not an either-or proposition. It's a both-and proposition."

California is at the leading edge of subsidizing the fuel cell movement. The state Legislature passed AB 8 late last year, dedicating $20 million a year through 2023 to finance the construction of as many as 100 hydrogen fueling stations.

There are only 11 such stations in California now, though that number could increase to 40 stations within a year.

Automakers and station owners have little incentive to invest without government subsidies to develop cars and stations.

"Without government support, this is not a viable business," Poppe said.

Until the nascent technology goes mainstream, hydrogen station operators like Poppe — who's such a believer in the technology that he and his wife both drive Mercedes-Benz B-Class fuel cell cars — must wait for their businesses to become profitable. His Burbank station serves 10 or

20 cars a day; he needs at least 30 to recoup his investment.

Experts put the price of building a single hydrogen fueling station, excluding the cost of the real estate, at about $2 million. A single nozzle at his Burbank station costs $12,000, Poppe said.

That's expensive, but so are gasoline stations — along with the drilling and refining operations that feed them.

"We could put in a nationwide network of [hydrogen] stations for less than the cost of building the Alaska pipeline," said Charlie Freese, head of the fuel cell vehicle program for GM. "There are a lot of other hidden costs too, like the cost of keeping the [Strait] of Hormuz open."